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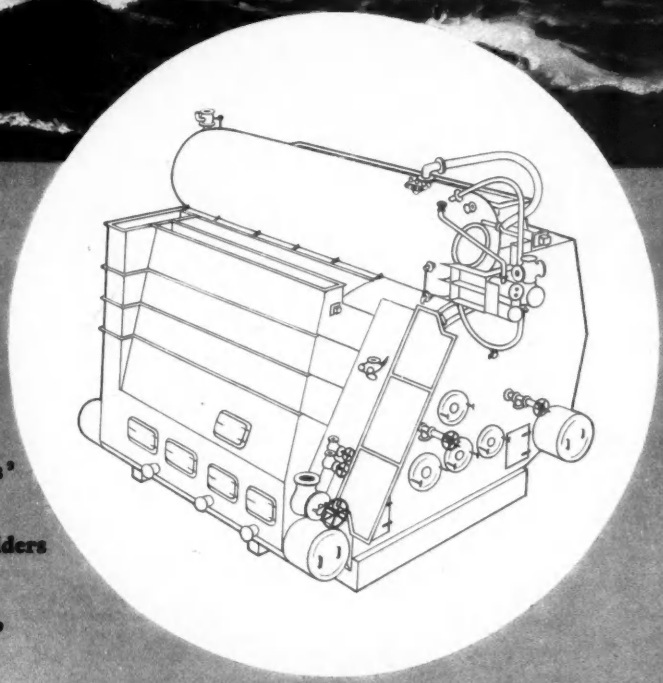

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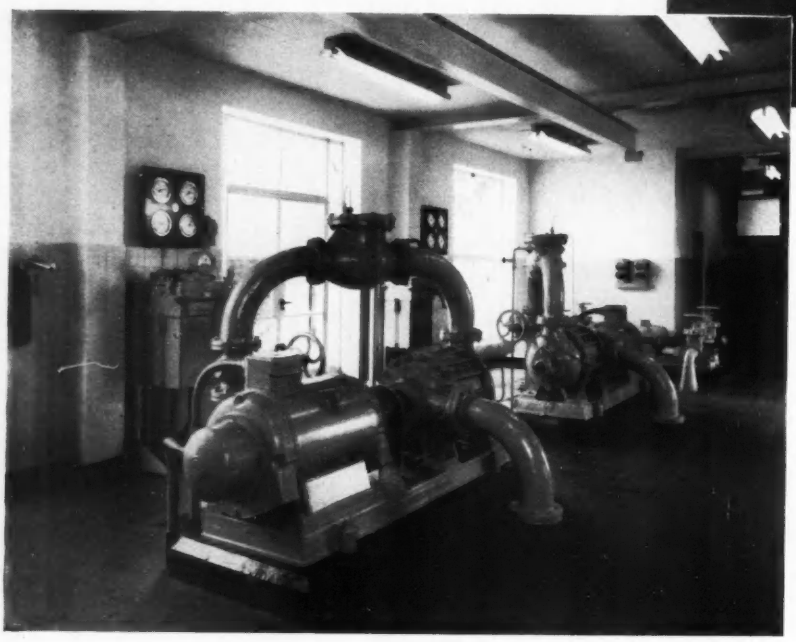

Glenfield Recoil valves and Sluice valves in pumping station of the Shell Brook Wat Supply Scheme of the Mid Sussex Joi Water Board.

Courtesy:— W. H. Ashmole, Esq., M.I.Mun. Clerk and Engineer to the Board.

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THE ENGINEER

APRIL 8, 1955

Sir Winston Churchill, K.G.

LAST Tuesday evening an official announcement from Buckingham Palace said that Sir Winston Churchill had had an audience of the Queen, when he tendered his resignation as Prime Minister and First Lord of the Treasury. The announcement added that Her Majesty had been graciously pleased to accept the resignation. Sir Winston Churchill, who celebrated his eightieth birthday in November last, took his first Government office in 1906, when he became Under-Secretary of State for the Colonies. He has served two terms as Prime Minister, the first of which began in May, 1940, at the most critical period of the second world war. Sir Winston's second term of office as Prime Minister began in October, 1951, with the return to power of the present Government. During his arduous years of office as Britain's wartime Prime Minister, and throughout the difficulties of the post-war years in which he has served, Sir Winston has had many associations with the engineering profession. At all times he has been quick to appreciate the essential contribution to the life of the nation made by engineers and scientists in war and in peace. Sir Winston is a Fellow of the Royal Society, a Fellow of the Royal Aeronautical Society, a Fellow of the Society of Engineers, an honorary member of the Institution of Naval Architects and of the Institution of Municipal Engineers, an Elder Brother of Trinity House, and an honorary Freeman of the Shipwrights' Company. Engineers at home and overseas, we are sure, warmly endorse the many good wishes that are being conveyed to Sir Winston as he relinquishes the premier office in the Government and retires to the role of an honoured elder statesman.

British Overseas Airways Corporation

IN a recent letter addressed to all members of the staff of the British Overseas Airways Corporation, Sir Miles Thomas, the chairman, stated that at the end of the financial year 1954/55 the Corporation showed a profit of about £1,360,000, and, after interest, a net surplus of about £260,000. Despite the many difficulties which had been faced the Corporation's projected fleet pattern had clarified. First, he said, the "Comet" situation had been settled in what he regarded as a most satisfactory way. Technical advances made by the Rolls-Royce Company to the "Avon" engine, and developments in the structural design of the airframe by the de Havilland Company, had resulted in the evolution of a Mark IV "Comet." The engines had 500 lb more thrust and 9 per cent better fuel consumption, which, with increased pod tankage, more than counterbalanced the extra weight built into the airframe to increase its strength. The outcome was an aeroplane of longer range, better economies and greater passenger attraction. Further, the "droop snoot" leading edge on the wings and larger flaps improved the handling characteristics of the machine at take-off and landing. Thus, wrote Sir Miles, there were distinct credits to offset the time lost as between the "Comet I" and the delivery of the Mark IV towards the end of 1958. The "Britannia" Mark 100 had done very well on her trials in Africa and it was hoped to introduce this machine into service next year on the African route and subsequently on the Australian and Far East routes. The extra "Constellation 749s" which had been acquired and were being modified in the Corporation's own workshops were already being placed in service on the Australian and other Eastern routes. The first of the converted "Stratocruisers" being added to the trans-Atlantic fleet had flown and others would be following in regular sequence. Sir Miles paid tribute to the way in which the "Argonaut" fleet worked during the difficult period the Corporation had passed through in the last twelve months. During the year they achieved an aircraft utilisation of 3440 hours, equivalent to 9·4 hours a day. In short, concluded Sir Miles, the Corporation was beginning to get the right tools and the right facilities, the forward fleet picture was clarified for planning, and forward bookings were encouraging.

Association of Supervising Electrical Engineers

THE annual dinner and reunion of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, on Friday, April 1st, under the chairmanship of the president of the Association, Mr. Brian Donkin. After the loyal toast had been honoured the toast of "The Electrical Industry" was proposed by Sir John Cockcroft, Director of the Atomic Energy Research Establishment. Sir John said that the electrical industry and atomic energy, which were linked by the recently announced programme for nuclear power stations, had much in common, including a very long gestation period. In the case of atomic energy fifty-one years had elapsed since Rutherford wrote of the store of energy in the atom. Sixteen years later the atom had been "split" by electrical means in the laboratory. By 1937 nuclear fission had become possible on a large scale and by 1942 the first atomic pile had been built, tentatively in the football ground of the University of Chicago, whence it was speedily transported to another destination as soon as it was discovered that it worked! To-day, Sir John went on to say, Great Britain was in a position to hope that atomic energy would fill the prospective gap between coal supply and demand by producing the energy-equivalent of 40,000,000 tons of coal annually by 1970. Replying to the toast, Mr. J. Eccles, president of the Institution of Electrical Engineers, recalled that Sir John Cockcroft was the first person to cause "forced nuclear fission." In that sense he was the father of nuclear power, and he was to be congratulated on what he had done, particularly since the war, to put Britain in the forefront in these developments. Mr. Eccles said that the Central Electricity Authority was planning a supply system that would provide, by 1975, three to three and a half times its present output of electricity, a fair proportion of which would come through nuclear power stations. The toast of "The Guests" was proposed by the chairman, Mr. Brian Donkin, the response was made by Sir Norman Kipping, director-general of the Federation of British Industries.

Road Safety Experiment at Slough

THE Ministry of Transport and Civil Aviation states that the 67,000 inhabitants of Slough are being invited to co-operate in a two-year experiment to determine the relative values of various road safety measures. It is expected, on analysis, to yield valuable information which can be used in formulating future policy on the prevention of accidents throughout the country. It is the first experiment of its kind in Britain. During the experiment selected road works will be carried out, an improved traffic control system introduced and road safety education and police activity considerably intensified. The road works may include the improvement of road junctions, traffic roundabouts, road widenings, lay-bys for buses, street refuges and guard rails. Courtesy police patrols are being considerably strengthened and will include motor-cycle patrols, and the patrols will give equal attention to all classes of road users, it is stated. There will be a house-to-house distribution of road safety literature and propaganda will be sustained throughout the experiment. Particulars of the improved traffic control system and other safety measures will be given when the experiment is started. The various activities will not all begin simultaneously but will be phased so that the effects of each may be measured as accurately as possible. During the first months the main emphasis will be on road safety education and police activity. Engineering works and other measures will follow. In 1954 road casualties in Slough totalled 470, including five killed and 134 seriously injured. The other casualties were slight injuries. The total included 183 pedal cyclists, 100 motor-cyclists, and ninety-six pedestrians. The detailed plans have been prepared by the Ministry with the help of the Slough Borough Council and of the Chief Constable of Buckinghamshire, the Road Research Laboratory, the C.O.I. Social Survey, the Royal Society for the Prevention of Accidents and other interested organisations.

Institute of Metals

THE annual dinner and dance of the Institute of Metals was held in London on Thursday, March 31st. In proposing the toast of the Institute and the non-ferrous metal industries, Sir Lawrence Bragg spoke of the valuable work the Institute was doing for industry, and how the way in which it kept abreast of developments was shown by the formation of a special committee to deal with metals for use in the atomic field. In responding to the toast, Dr. Maurice Cook, the president of the Institute of Metals, pointed out that not very many years ago about six metals carried the weight and wealth of the world, whereas now there were thirty to forty strategic materials in use. At the present rate of consumption the known supplies of some of these metals would be exhausted in less than a hundred years. On the other hand, new light metals were being established industrially and would give spectacular results in the not too distant future. In his response to the toast of the guests, proposed by Mr. John Grimston, Sir Sydney Camm said that the aircraft industry owed a debt of gratitude to the light metals industry, for without aluminium flight would have been impossible in the early days of the aeroplane. In more recent years advances in jet propulsion of aircraft had been made possible by the development of metals with suitable properties.

Historic Reinforced Concrete Building

IN the April issue of the *Journal of the Institution of Structural Engineers* an account is given by Professor Fisher Cassie of a house of reinforced concrete construction built in Newcastle upon Tyne in 1865 by William Boutland Wilkinson. Wilkinson took out a patent in October, 1854, from which, Professor Fisher Cassie states, it is clear that he was one of the first to think of, and to produce, structural reinforced concrete. His patent describes reinforcing with flat bars or with second-hand wire ropes from collieries, which, he points out, should be inserted where the tension is expected, and indicates clearly that he understood the distribution of tension in a beam. Lambot exhibited his famous reinforced concrete boat a year after Wilkinson's patent, and it is suggested that Wilkinson's ideas were distinctly in advance of Coignot and Lambot's work with light mesh reinforcement. The house at Newcastle was recently demolished, but a thorough inspection of it has been made and recorded. It was in excellent condition, we understand, and was entirely of reinforced concrete, including the stairs and chimney. Its construction has many points in common with present-day methods. The first floor consisted of precast plaster moulds, which had been supported in position on timbering, while old colliery ropes were laid between them in a rectangular pattern, to give cast-in-situ concrete beams and a floor slab. Test cubes 2in in size were sawn from the concrete; they gave an average compressive strength of 3800 lb per square inch and a maximum of 4500 lb per square inch.

Damodar Valley Project

BY OUR INDIAN CORRESPONDENT

No. II—(*Continued from page* 441, *April* 1*st*)

Considerable interest has been aroused by the progress of the Damodar Valley Corporation's development schemes. The first stage of development is due to be completed in 1957*; it involves* 300*MW of electrical power, a million acres of irrigation, about* 100,000 *acres of land reclamation, and navigational facilities.*

OF the seven dams in the development scheme for the Damodar Valley, four have been included in the first stage now nearing completion. Tilaiya and Maithon dams are on the Barakar river, a tributary of the Damodar. The Tilaiya dam, sited at the uppermost reach about 130 miles above the confluence of the two rivers, is the first to be completed so far, and Maithon, near the confluence, is expected to be finished by 1956 or thereabouts. Tilaiya dam is also the first to be completed anywhere in India since the end of the war, and is also the first concrete dam to be built in the country. It is not, however, the smallest dam of the D.V.C., being a concrete gravity structure, 94ft high above the deepest river bed and 1147ft long at the road level. At the dam site, the river bed is about 300ft wide, the left bank rising with a slope of 1 in 5·5 for the first 100ft, and then about 1 in 16 to the crest. The right bank is somewhat flatter, rising 100ft in 950ft, and then the next 50ft to the top of the ridge in about 750ft. There is good quality rock available at the dam site, a 400ft wide belt consisting of quartzites dipping almost vertically, running across the ridge at the site. Upstream of the quartzite belt occurs mica schists interspersed with quartz veins, while downstream of the belt outcrops of finely decomposed fine-grained granite-gneiss are found. Much of the ridge is covered with quartzite debris and weathered surface rock to about 5ft to 10ft of depth. The river bed proper is covered with a layer of river sand varying in depths from 5ft to 40ft. [3, 4]

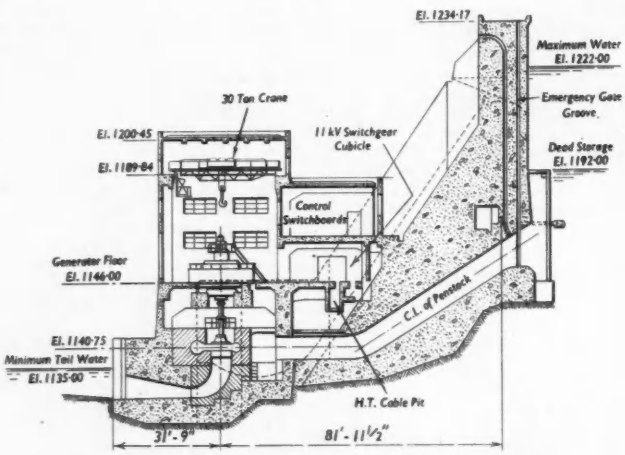

Fig. 6—Cross section of the Tilaiya dam and power-house

The dam is principally for irrigation but the head obtained is being utilised for power generation. The spillway is 510ft long, including the piers, almost half of the total length. The right and left abutments are 407ft and 230ft long, respectively, and the power house is on the left bank immediately below the abutment. The spillway discharge is controlled by fourteen sector gates, each 10ft high by 30ft long, and the two under-sluices, 30in in diameter, help to dispose of the maximum design flood of 132,000 cusecs. The dam impounds a reservoir with a capacity of 320,000 acre-feet at the top-of-gate level, of which 260,000 acre-feet (from level 1222 to 1192) is the live storage. Uncontrolled flood storage (from level 1230 to 1222) is 130,000 acre-feet. The average tail-water level is 1135, thus giving a maximum head of 95ft and a minimum of 57ft for the turbines. A cross-section of the dam and the power house is given in Fig. 6.

The power house (Fig. 7) is designed for two 2MW generators, with provision for a third set at a later date. About 22 million kWh are expected to be available per year, of which a little over 9 million will be secondary power, available only during the monsoon, after the station is linked with the D.V.C. grid. This is expected to meet the demand for power in the adjoining areas in the initial stages of development, since there are no industries nearby, and the area is only sparsely populated. The two units, commissioned in 1953 (THE ENGINEER, March 20, 1953), are of Japanese manufacture, the first of their kind to be used in India. The Mitsubishi Electric Manufacturing Company and Central Japan Heavy Industries, Ltd., who supplied the generating units, including the turbines, were also responsible for the supply and installation of all auxiliaries, switchgear, transformers and the outdoor substation. The tender price was approximately £90,000, about a third of the price quoted by European and American manufacturers.

The turbines and auxiliaries are designed for remote-controlled operation; the circuit breakers are solenoid-operated, and the entire plant is capable of central control from the control room, annunciation being provided by lights and instruments for indicating

Fig. 7—Tilaiya dam and power-house from left bank

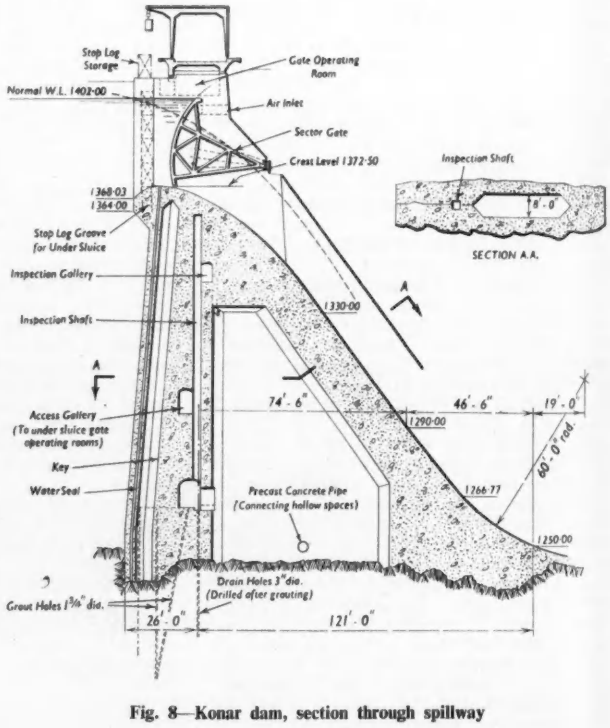

Fig. 8—Konar dam, section through spillway

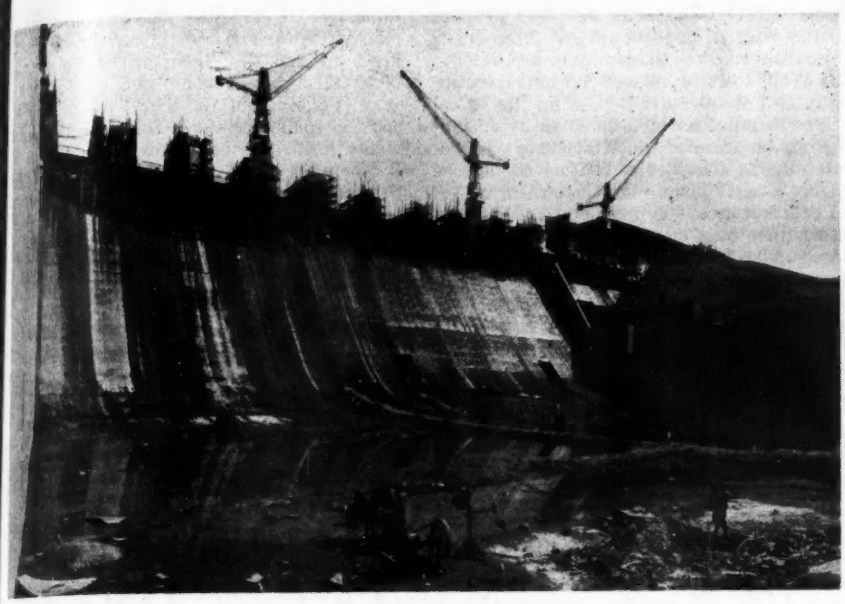

Fig. 9—Konar dam showing the spillway

the operating conditions at every stage. The control is provided by an oil-pressure system, and the control apparatus consists chiefly of solenoid-operated oil valves and oil-pressure relays closing or opening electrical circuits. The main characteristics of the power plant are given in Table II.

TABLE II—*Characteristics of Tilaiya Generators and Turbines*

Turbine :	
Rated output	2,800 h.p.
Maximum head	100 ft
Rated head	64ft
Minimum head	49ft
Efficiency at full load and rated head	88·5 per cent
Speed	250 r.p.m.
Discharge for the rated output and head	438 cusecs
Diameter of penstock	7·5ft
Runaway speed under rated head	487 r.p.m.
Number of runner vanes	15
Number of guide vanes	20
Generator :	
Rated normal output	2,500kVA
Output on overload for 2 hours	3,000kVA
Power factor	80 per cent
Terminal voltage	11,000 volts
Max. efficiency at 100 per cent p.f.	95 per cent
Weight with exciter	58 tons

One interesting feature of the erection was the shrinking of the rotor on to the main shaft.[3] The rotor was induction heated by winding twenty-two turns of 0·15 square inch of copper conductor ; 220V, 50 c/s, single-phase current was applied to this winding, and 260A were taken from the mains. The required temperature rise of 100 deg. C. was reached in about 14 hours.

The Tilaiya project is the only Damodar project to be executed without consultants, either Indian or foreign. The work was done departmentally by direct labour, small local contractors being used for casual jobs. The work was actually commenced in January, 1950, but the placing of concrete was not begun until a year or so later. At first, concreting was done by the traditional Indian method of a " human chain of head baskets," a method not without its advantages in a country where machinery, its installation, maintenance and running can be almost four times as costly as direct labour, but ill-adapted for large-scale construction projects like dams and power stations. By December, 1951, the construction plant had been fully mechanised, the equipment consisting of two Lima 2½ cubic yard draglines, one Northwest 1½ yard shovel dragline, two Blaw-Knox concrete batching plants with 2-yard capacity tilting mixers, one Baxter 50-tons per hour stone crusher, one Cedarapids 50-tons per hour primary and secondary stone crusher, six Blaw-Knox bottom dump concrete buckets of 2-yard capacity, thirteen air compressors, from 300 to 500 cubic feet capacity, six diesel-driven locomotives for hauling concrete buckets, and six Chicago pneumatic concrete vibrators.

Two 2½-yard capacity Lima draglines were converted into concrete-placing cranes. These handled the bottom-dump buckets and placed concrete in 4ft layers. At the end of the given cycle across the dam, the draglines were walked up to a 4ft higher elevation on to an adjacent block on a wooden ramp, where they continued concreting on the next lift. At the end of the final concreting, the two cranes were walked from the dam on to either embankment.

The dam was completed early in 1953 and the power station, which was commissioned by Mr. Jawaharlal Nehru, in February of that year. The whole works are stated to have cost about Rs.4 crores (£3,000,000), although it is said they would have cost less had the work been entrusted to a contractor. After completion and, in fact, during construction also, when the reservoir was being filled, water was observed oozing on the downstream face, particularly through the joints. At one time it was felt that this would call for serious repairs. There were questions and answers in Parliament and the chairman of the D.V.C. had to step in with a denial that the dam as such was in peril. After a fairly long programme of pressure-grouting, the oozing has ceased and the dam has withstood two monsoons and two floods without any hint of instability.

KONAR DAM

The Konar dam has a threefold purpose[1] : irrigation, power and supply of cooling water to the Bokaro thermal station at a steady rate of 400 cusecs when the station is in full operation. This station, which is on the banks of the Konar River about 12 miles below the dam site, has been provided with a 20ft high weir sufficient to impound a storage of 60,000,000 cubic feet directly controlled by releases from the Konar dam. The final scheme for power generation is in the process of development and out of five or six schemes under consideration at one time, it appears from the latest progress[8] report that an underground power station immediately below the dam will be selected, as the most economic from the power point of view, although not so desirable from the constructional point of view. The scheme, as at present envisaged, will consist of an installation of two 20MW units working under a maximum head of 600ft at full storage level and at about 550ft at maximum drawdown. The tail-race tunnel will be 7½ miles long. It is expected that the plant will have an average annual output of about 200,000,000kWh, of which nearly a quarter will be secondary energy available only during the monsoon. It is most unlikely that the power station will be completed before 1957, for up to the time of writing no start had been made on construction. If the scheme does go through, the power station will be the first in Asia, although another hydro scheme south of Bombay will soon be busy with its underground station at Koyna, with a capacity six times that of Konar. The irrigation benefits due to Konar are about 104,000 acres of irrigated area, almost equal to that accruing under Tilaiya.

Neither Tilaiya nor Konar reservoirs have been provided with any flood reserve as this has been concentrated at the last two dams, viz., Maithon and Panchet Hill. According to the consultants, " the flood storage, if scattered over seven dams in the valley, would lose much of its effectiveness. Generally storms in the valley are local and so the flood-control provisions in the dams of the upper reaches may be partially or wholly ineffective." Both Tilaiya and Konar dams will, therefore, store water for irrigation and power only, the latter, however, acting, in

Fig. 10—Konar earth embankment under construction

addition, as a controlling headworks for the cooling water pond at Bokaro.

The Konar dam, on the River Konar, about 20 miles upstream of its confluence with the Damodar River, will impound 260,000 acre-feet of water at level 1402 (top of gates), about 156ft above river bed. The concrete dam, 910ft long at the base with transverse joints spaced at intervals of 40ft in the spillway section and 50ft in the abutment section, is a straight gravity structure. It has earth embankments on either side (Fig. 10), the left one about 4000ft long and the right one 5800ft long. There will also be a saddle dyke 2200ft long with a maximum height of 22ft. The spillway is controlled by nine sector gates (Fig. 8), each 32ft high and 34ft long. In addition, there are two under-sluices, each 7ft 6in in diameter.

Hollow spaces 10ft wide and 61ft long are provided between the blocks in the abutment section, the rear face of which has a slope of 1 in 0·75, and closes at RL.1330. (The two end blocks on either side of the spillway form abutments to take the thrusts of the earth

TABLE III—*Brief Statistical Data on Tilaiya and Konar Projects*

	Tilaiya dam	Konar dam
Catchment area, square miles ...	380	385
Flow :		
Maximum, cusecs	48,439	20,645
Minimum	Nil	Nil
Average, cusecs	560	560
Storage :		
Total, acre-feet	320,000	260,000
Live, acre-feet	260,000	211,000
Dam :		
Height, feet	98	160
Length, feet	1,147	910 (concrete dam) 9,800 (earth embankment) 2,249 (saddle dykes)
Spillway capacity, cusecs	131,500	240,000
Benefits :		
Irrigation, acres	99,000	104,000
Power :		
Installed capacity, MW ...	4 (present) 6 (future)	40 (proposed)
Total units per year	22·770 million	191·000 million

dam.) Similarly, the hollow space in the spillway section is 8ft wide and 60ft long and closes at the same level as in the abutments (Fig. 8). According to the consultants, this construction[6] provides the following main advantages :—

(*i*) The hollow spaces release the uplift pressure as they start almost from the rock foundation and the water can escape freely into the space whence it is collected in the abutment section through the 4ft diameter pipes provided in the blocks connecting the spaces, and then led out into the stilling basin through galleries in the retaining walls.

(*ii*) As the spaces are well-ventilated and have free air space, they hasten in the cooling of concrete, as the distance of travel for the heat is reduced to a length of 16ft only in the spillway section and 20ft in the abutment sections.

(*iii*) A saving of 6 per cent of concrete is effected. The total volume of concrete is about 400,000 cubic yards.

As against this there are disadvantages such as practical difficulties in erecting and dismantling of shuttering. But the general concensus of opinion on site is that the advantages far outweigh the drawbacks.

Construction work on the dam was begun in October, 1950. Dewatering presented no great problem, for the foundation rock is fairly good, consisting mainly of granitic gneiss and intrusions of pegmatites, quartz veins and altered felspars. Crushing and screening of aggregate is done mechanically through a new I.B.A.G. crushing and screening plant. Concrete mixing is done by three I.B.A.G. concrete mixers of 1500 litres capacity (1·31 cubic yards), and Lummhoff buckets of equal capacity carry the concrete to the place of deposition, and three hoists raise the buckets to the service bridge, whence the Wolff tower cranes of 3·5 tons capacity (57ft boom) take over. During the initial stages as much as 1200 cubic yards of concreting was achieved which tended to go down later on as the blocks became smaller at higher levels. There were three main classes of concrete used, the main body of the dam using three bags of cement (per cubic yard), three-and-a-half bags for subnormal foundations, and four-and-a-half bags for a 5ft to 7ft thick skin on all the faces exposed to atmosphere and water. The average crushing strengths after twenty-eight days were, respectively, 3587 lb per square inch, 3928 lb per square inch and 4774 lb per square inch.

The entire construction work has been let to the Hind Construction Company and Patel Engineering Company, Ltd., of Bombay, and although there was, at first, some difficulty as regards heavy construction machinery, such as cranes, shovels and draglines, this was soon overcome and the main concrete dam was completed by May last year (Fig. 9), but for a few minor details such as road slab, &c. The earth embankments have also been completed. Gruner Brothers, of Basle, Switzerland, designed the dam and supervised the construction. Table III gives a brief statistical summary of the two projects.

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* These are official publications of the Damodar Valley Corporation, Anderson House, Calcutta, 27, India.

(*To be continued*)

Progress in Non-Ferrous Metals

By DR. MAURICE COOK

No. II—(*Concluded from page 447, April 1st*)

Here are reprinted extracts from the Presidential Address delivered by the author before the Institute of Metals on Wednesday, March 30th. Dr. Cook surveyed broadly the progress in non-ferrous metallurgy between the termination of the first world war and the present day, dealing particularly, but not exclusively, with wrought non-ferrous metals and alloys.

IMPURITIES

FROM the results of research of immediate technological interest that has been going on in recent years, we know enough about impurities and their influence on metals to appreciate not only the beneficial effect of high purity, but also that a pure material is not always, and in all circumstances, better than one which is less pure. From this work we have learned much in a few years and we know, for example, that small amounts of elements fortuitously present, or deliberately added to a metal, can affect its properties, or some of them, to a most pronounced degree. We know also that the purity not only of the parent metal but of the alloying metals can markedly influence the quality, properties and serviceability of the resulting alloy. This whole question of purity of metals and alloys is one of the greatest possible importance and significance in both their processing and use, and the successes that have been achieved in producing primary metals to high purity standards must certainly rank amongst the most outstanding advances that have been made in the past two or three decades.

Usually the corrosion resistance of a metal increases with its purity. With magnesium, which affords a notable example of this, remarkable improvements have been obtained in the corrosion resistance of the metal itself, its alloys and alloys in which it is a major constituent, by reducing the amount of impurities. Aluminium is another well-known case where availability of high purity metal has had a significant effect on the extended uses of the metal itself and also on its alloy technology. But the light metals are not alone in this, and other base metals, too, can now be obtained in high purity grades. The advent towards the middle twenties of high purity zinc, that is, not less than 99·99 per cent, provided a turning point in the evolution of zinc base die casting alloys, which represent the most notable single new use for zinc that had been developed during this century. Castings in these alloys that had so far been produced were prone to distortion, corrosion and dimensional instability, and the work in 1922 of Brauer and Peirce, which showed that this was associated with the presence of small amounts of tin, lead and cadmium, pointed the way to the production of vastly superior castings by using alloys made from high purity zinc.

Just how significant the restriction, to a low limit, of a commonly occurring impurity can be in influencing production practice is illustrated by lead in alpha brass. Until a few years ago it was usual in making strip and sheet in alpha brass alloys to cold roll throughout. With the need for processing much larger ingots into wider and longer coils the attractiveness of initial hot rolling was clear enough, but only became possible and generally adopted, as it has been, by limiting the lead content to a maximum of 0·02 per cent, although other considerations and some specifications would tolerate a much higher figure.

There are also many instances of the remarkable and beneficial effects which can be produced in well-known alloys, both ferrous and non-ferrous, by small additions of elements other than the alloying ingredients themselves. I will mention but two. Aluminium-silicon alloys nowadays are a familiar group of light foundry alloys, and although they have been known for a very long time, they only attained industrial importance after Pacz had shown, in 1920, that the properties of the eutectic alloy could be vastly improved by the addition of small amounts of sodium or other alkali metals. Much more recently, we have a comparable example of beneficial structural modification in the production of nodular cast iron by inoculation of the melt with a small quantity, that is about 0·1 or 0·2 per cent, of cerium or magnesium, and irons so treated are far stronger and tougher than those in which the graphite is present in the usual flake form.

There has been no tardiness on the part of industry in making use of these and many other such discoveries and findings, some of

them accidental and most of them empirical, concerning the effect of small amounts of added elements. The results have so often been so very rewarding that it is surprising much more work has not been done to obtain a fuller understanding of these effects and how they are brought about, and I cannot but think that studies in this field merit more prominence and a greater share of the available research effort than they at present receive.

Titanium

Titanium was discovered in 1790, but for 135 years knowledge of its properties was hidden from us by the masking effect, as we now know, of impurities, such as oxygen and nitrogen in particular. Prior to 1925, it was known only as a brittle unpromising metal, but in that year the Dutch chemists van Arkel and de Boer, produced metal of about 99·9 per cent purity, which was quite different from that hitherto made, inasmuch as it was very ductile and readily workable in the hot and cold states. Elegant though it was, the method used by van Arkel and de Boer of thermally dissociating the tetra-iodide of titanium formed at much lower temperatures could not be, and has not yet been, translated into an industrially workable process. However, as a result of their work, it became possible to determine the real properties of titanium, and this information pointed the way to an important and growing future for the new metal. The worth-while objective was there for the development of a less-costly extraction process which would yield acceptably pure metal. To Kroll, working at that time in Luxembourg, goes the credit for devising and developing the first process to be used on an industrial scale for the extraction of titanium. In 1940, he was granted a patent for the production of titanium by reduction of the tetra-chloride with metallic magnesium, with subsequent removal of the residual magnesium and magnesium chloride by leaching. This pioneer work was continued in the U.S.A. under the auspices of the Bureau of Mines, and details of the various techniques developed were made known in 1946. Industrial production started modestly in the U.S.A. in 1948 with an output of about 15 tons. In 1954 this probably reached, in total for the world, although most of it was American, about 4000 tons, and the capacity of existing and projected plant in the U.S.A. is reputed to be about 35,000 tons. It has been suggested that the demand could soon reach six figures, and it would seem quite probable that an output of this magnitude might well be achieved in the next few years.

Welding

Particularly over the last twenty years a vast amount of work has been carried out on the metallurgy of welding processes, and this has led to many notable developments in welding practice and the increasing use of welding as a method of construction. It is in this period, and as a result of this work, that so much progress has been made in the welding of non-ferrous materials which before then was but an indifferently successful and not very extensively used joining technique. For fusion welding, the processes so generally and satisfactorily employed for steel, that is gas, metal-arc and carbon-arc welding, were adopted in the absence of others, for welding non-ferrous metals, but they have not generally proved suitable for the production of high-quality welds. It was the advent during the war years of the argon-arc process, and subsequently of the argon-shielded metal-arc process, that so greatly changed the position in providing a means whereby consistently sound strong joints could be produced in such materials as aluminium and copper-base alloys. In these processes, the use of flux, with its attendant disadvantages, is not necessary, since the heated metal is shielded from the atmosphere by a blanket of inert gas. Moreover, the high rates of heat input that can be achieved are of particular value in welding materials of high thermal conductivity, and enable heating to be confined and so minimise cracking and distortion. In the argon-arc process, either direct or alternating current can be used, and with the latter, in the half cycle in which the electrode is at positive potential, a cleaning action, essential in welding such materials as aluminium, magnesium and aluminium-bronze, which possess resistant oxide films, is effected on the metal surface. In the argon-shielded metal-arc process, a similar result is obtained, and because of the very high current density in the electrode wire, and consequently the strong magnetic field surrounding the arc, the metal is transferred as a narrow column of fine spray, rather than as droplets. This directional effect, which is so pronounced that welding can be carried out in all positions, and the high thermal efficiency which results in high rates of metal deposition and consequently high welding speeds, make the process especially attractive for constructional work.

Tin Plate

Tin plate, of course, is essentially a ferrous product. This commodity accounts for about half the total consumption of tin, and its annual output, which runs into millions of tons, is produced on some of the most imposing plant employed in the metallurgical industry. The changes that have revolutionised production methods have been the introduction of large powerful mills for rolling wide strip in coils weighing several tons, and of electrolytic tinning with the consequent creation of an effectively integrated large-tonnage continuous process yielding a product of consistent quality. These plants, indeed, impress by their immensity, capacity and efficiency, and the accomplishment of implementing, within one decade, research work on electro-tinning into a continuous industrial process on a vast scale, must surely rank as one of the most striking metallurgical successes of our time.

Analytical Control

Since the properties of metals and alloys are so closely and largely determined by their composition, analytical control has always been a necessary and important feature in the wrought non-ferrous industry. To-day it is, with the increased volume and variety of production, and the existence of an ever-increasing number of specifications with stringent compositional clauses, more important than ever. But apart from specification requirements, effective analytical control, which implies quickly available accurate analytical results, is indispensable to many of the more recently developed processing techniques. Fortunately, considerable attention began to be directed years ago to the development of rapid and accurate analytical procedures, and the success that has attended these efforts, which very rightly and wisely have been continued, represents, in my view, an outstandingly valuable contribution to the progress of the industry. It seems to me doubtful if the importance of this work, on one of the industry's ancillary but most essential services, has been generally or sufficiently appreciated.

The spectrograph has been by far the most useful of the various physical methods that have been devised, for its successful application in non-ferrous analysis has made it possible for results to be obtained in the space of minutes rather than hours, or longer, with an enormous saving of manpower. The values of these techniques is reflected by the statement of Twyman to the effect that during the war there must have been about 500 spectrographic outfits in use in Great Britain alone, for controlling the production of industry. In this field, research was undertaken by the British Non-Ferrous Metals Research Association in 1925 and has continued ever since. It is a notable example of highly successful co-operative research. The first paper dealing with industrial applications of spectrographic techniques, published in 1923, recorded results obtained in an American laboratory with a British instrument, and the first papers on this subject in the *Journal* of the Institute appeared in 1931. In the early years of their employment in industry spectrographic methods were limited to the detection and estimation of small quantities, by means of visual examination of spectra recorded on photographic plates. Later, however, the barrier-layer photo-cell made possible the production of a micro-densitometer, with which densities of recorded lines could be accurately measured, thereby greatly extending the scope of spectrographic methods. The great advances in electronic design and components during the war led to a radical change in spectrographic procedure, by the use of electron multipliers for recording directly, and immediately, the intensities of radiations. Direct-reading spectrometers became available in the U.S.A. in 1945, and they have been followed by others made in this country and elsewhere. As a class, they are certainly the most efficient analytical instruments so far developed, inasmuch as they provide for the accurate, rapid and economical estimation of most, if not all, metallic elements.

During the thirty-six years that have come and gone since the termination of the first world war our knowledge of metals has been vastly increased and profoundly deepened. As a result of this, and the immense strides forward that have been made in production technology, in improving processes and products and in developing new ones, the industry has grown greatly both in size and importance. Impressive as all these achievements have undoubtedly been, I think we can, with every confidence, look forward to still more outstanding advances in the future and this Institute, I am sure, can and will help importantly in their fulfilment.

Code of Practice

ZINC ALLOY PRESSURE DIE CASTING FOR ENGINEERING.

C.P. 3001 : 1955. Price 5s. The British Standards Institution announces the publication of a Code of Practice, C.P. 3001 : 1955, "Zinc Alloy Pressure Die Casting for Engineering," which has been prepared jointly with the Institution of Mechanical Engineers.

This code has as its objective the establishment of recognised practices in the design, production and inspection of zinc alloy die castings, in order to ensure that the materials used, the procedures followed and the design of the castings, shall provide a product that is reliable in every respect.

Zinc alloy die castings will perform satisfactorily in service only if they are free from contamination by certain elements harmful to the mechanical properties and corrosion resistance. The code, therefore, states that it is essential that these elements should not be present in higher proportions than those indicated in B.S. 1004, "Zinc Alloys for Die Casting."

Attention is drawn to the fact that a revised edition of B.S. 1003-4 has recently been issued, and that arrangements have beeen made for the use of the B.S.I. Certification Mark by manufacturers who hold a licence, and who are required to ensure that the whole of their production of zinc alloy die castings complies with Part 2 of B.S. 1004.

High-Precision Electric Dynamometers

By D. FIRTH, A.M.I.Mech.E.*

A high-precision swinging-frame electric dynamometer has been developed for measuring the efficiency of hydraulic machinery. It is accurate within ±0·1 per cent of full-scale torque and is reasonably portable. Novel features include pneumatic trunnion bearings, hydraulic torque measurement, and electronic speed control to within 0·1 per cent over a wide range. The development of the design is described and design considerations for larger dynamometers are examined.

HIGH-PRECISION electrical dynamometers were required for the new hydraulic machinery building of the Mechanical Engineering Research Laboratory, East Kilbride. Accuracies within ±0·1 per cent of the full-scale torque and the rotational speed were required and the dynamometers were to be capable of being easily moved around the building. As conventional dynamometers did not meet these requirements, a special design was developed at the Laboratory, using a converted d.c. motor, giving 25 h.p. at 3000 r.p.m. Novel features including pneumatic trunnion bearings, hydraulic torque measurement and electronic speed control, have resulted in a unit of unusually high accuracy. The development work has also suggested new ideas for larger dynamometers.

Trunnion Bearing Design

Three types of trunnion were investigated : simple ball-bearing pedestals, ball-bearing pedestals with the outer races rotated, and pneumatic bearings. The bearings were fastened to the end shield facings of the dynamometer and the whole assembly was mounted on a base plate. With the conventionally mounted ball-bearing trunnions, friction introduced an error of ±0·9 per cent of the full-load torque of the dynamometer, even though great care had been taken to align the pedestal bearings correctly.

The same ball races were supported in needle roller bearings and the outer races were rotated in contrary directions by variable-speed electric motors (Fig. 1). This

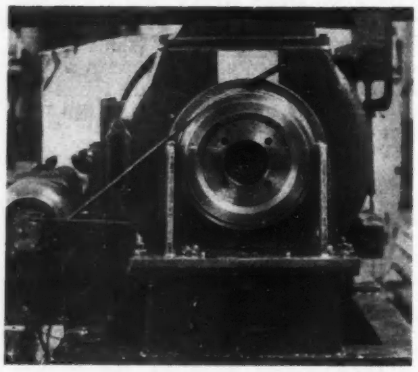

Fig. 1—Ball-race supported in needle roller bearings and arranged for rotation in a direction opposite to that of the shaft

reduced the frictional loss to 0·007 per cent of full-load torque, after taking special care with alignment and lubrication. The same frictional loss was obtained with a similar set of bearings. Although the friction of the two contra-rotated bearings on the dynamometer was not exactly comparable, it did not vary greatly with speed. A speed of 45 r.p.m. was used to prevent the introduction of vibration from the driving motor. The best lubricant found was a light machine oil thinned with paraffin. Some "running in" of the bearings was noticed. This, together with the fact that bearings with different friction/speed characteristics had been used, suggest that an even lower frictional loss could be obtained by using selected bearings that had been carefully "run in."

It was decided to use pneumatic bearings for the 25 h.p. dynamometer. They were

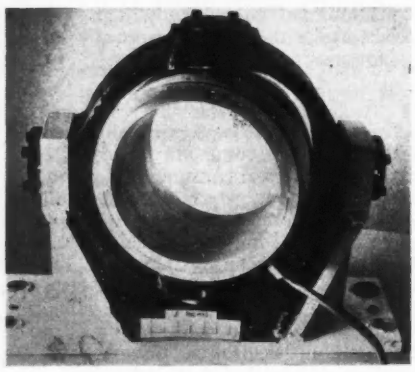

Fig. 2—Pneumatic bearing for 25 h.p. dynamometer, designed as simple sleeve bearing with the journal suspended in gimbals

designed as simple sleeve bearings with the journal suspended in gimbals (Fig. 3). This enabled each bearing to find its best alignment, thus eliminating the need for costly precision manufacture elsewhere. Air at 80 lb per square inch pressure was fed into each bearing through twenty circumferential holes, 0·021in in diameter. The bearings (Fig. 2) were 5in diameter by 6in long with a diametral clearance of 0·0035in, and

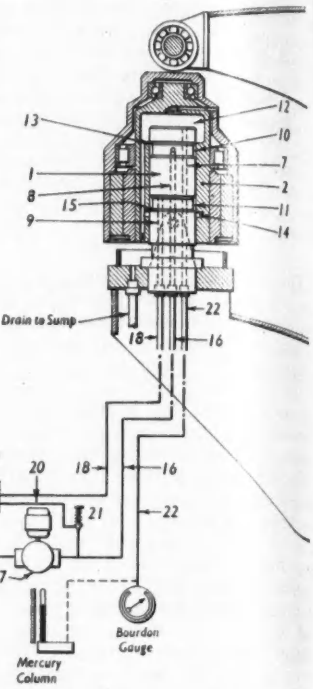

Fig. 4—Equipment for measuring torque below 1600in-lb

together supported a total load of 1100 lb. The friction of these bearings was too small to be measured when in clean running condition, but a very small amount of dirt greatly increased the coefficient of friction. To meet this requirement for clean air, the air compressor should be of the "oilless" type fitted with aftercoolers, a drier and an efficient filter.

A disadvantage of pneumatic bearings is their large air consumption. These bearings used 15 cubic feet of free air a minute, but the air supply was required only when a torque reading was made. Another disadvantage of pneumatic bearings is their size compared with that of the dynamometer being supported. The proportions are reasonable for small units, but the bearings become disproportionately large for dynamometers above about 25 h.p.

Oil-lift trunnion bearings[1] are probably suitable as frictionless bearings for larger dynamometers. They are similar in principle to pneumatic bearings, but higher pressures are obtained with lower flow rates by using oil in place of air. The dimensions of these

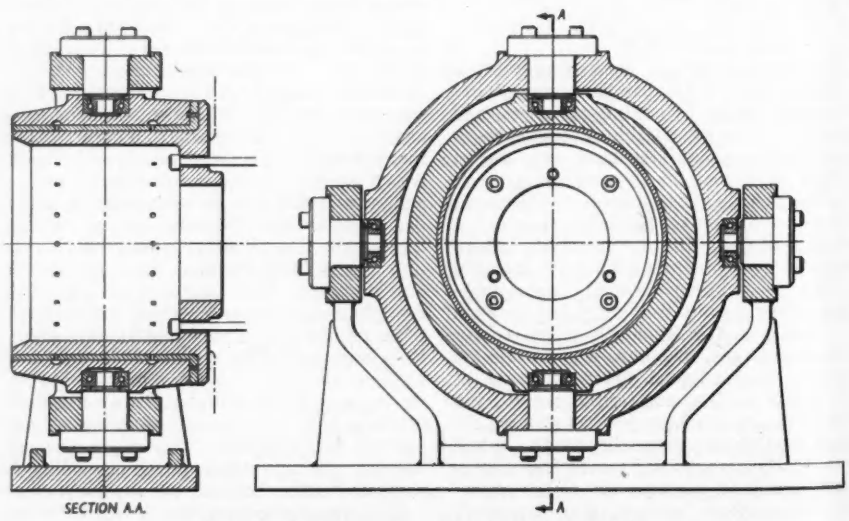

Fig. 3—General arrangement of air bearing pedestal

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bearings are, therefore, smaller and the cost of the high-speed oil pump is less than that of the air compressor. By using oil of low viscosity, it would seem that the coefficient of friction would be sufficiently low to meet the requirement of high-accuracy dynamometers. They also have certain disadvantages: as with air bearings, dirt particles

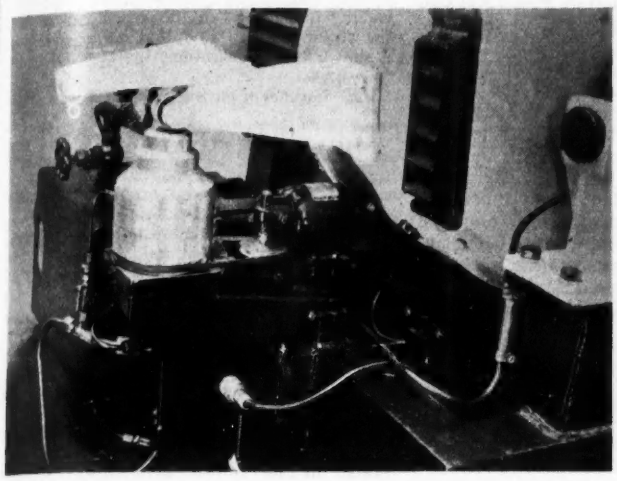

Fig. 5—Assembled unit for measuring torques below 1600in-lb

are inimical to high sensitivity; temperature changes in the oil produce variations of film conditions in the bearing, and the possibility of leaks from the oil system calls for special protection of other parts of the dynamometer.

Torque Measurement

The unit for measuring torque below 1600in-lb is shown in Fig. 4. It comprises a rotating hydraulic valve on a stationary piston operated by an arm extending from the carcase of the dynamometer. The piston 1 contains three ducts 7, 8, 9, the duct 7 opening in the upper end of the piston and the ducts 8, 9 into the grooves 10, 11 in the piston near its upper and lower ends. At the upper end of valve 2 is an enlargement 12 which forms an upper shoulder 13, while a groove 14 in its wall defines a lower shoulder 15. A duct 16 connects this groove 10 with the enlargement 12. The distance between shoulders 13 and 15 is equal to the distance between the outer edges of the grooves 10 and 11 in the piston. Thus, in the null position shown in Fig. 4, these shoulders are in register and both piston grooves covered. The null position is indicated by a steady pressure reading. Immediately the cylinder moves axially communication is established between the cylinder space and one or other of the grooves.

The upper groove 10 communicates through its duct 8 with a pipe 16 with a continuously driven gear pump 17, so that if the cylinder descends, liquid under pressure is admitted to raise the cylinder until it again reaches the null position. Similarly the lower groove 11 communicates through its duct 9 and a pipe 18 with the sump 19, so that if the cylinder rises above the null position, oil can escape to the oil sump until the cylinder returns to the null position. A small negative lap of 0·0015in was found necessary for stable operation. The gear pump 17 draws from the sump 19 and, to provide for conditions when the cylinder is at or above null position, a relief valve 21 discharges the pump supply back to the sump. The assembled unit is shown in Fig. 5.

Pressure from the cylinder head is transmitted through duct 7 and pipe 22 to a pressure measuring instrument. In the tests described this was a 2m mercury manometer reading to 0·02mm, which was the maximum sensitivity of the installation. The unit thus works satisfactorily with a Bourdon test gauge, which can be arranged for remote reading, but the accuracy and the sensitivity is not as high as with the mercury column.

To minimise friction the cylinder was rotated relative to the piston, thus maintaining a continuous fluid film between the working surfaces. Provided that dust particles can be filtered from the hydraulic fluid, wear can thus be almost eliminated. Michels[2] has demonstrated the effectiveness of rotation and an accuracy of 1 part in 10,000 has been claimed[3] for deadweight gauge testers which use the same principle. Only secular changes can affect the calibration and such effects can be eliminated if stable materials are used.

Other well-established methods are to impose a high-frequency "dither" to one of the components or a high-frequency pulsation to fluid between the pressure sensing and measuring elements. However, as it was considered important in the interests of accuracy to avoid pulsations, the rotational technique was adopted.

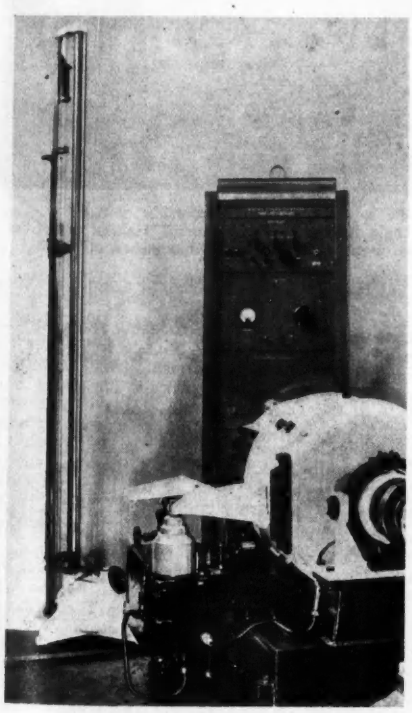

Fig. 6—The 25 h.p. dynamometer

The Dynamometer Assembly

The 25 h.p. dynamometer is shown in Fig. 6. The motor carcase, with its supporting feet cut off flush with the body, was mounted via the pneumatic bearings on a rigid frame fabricated from mild steel. The torque arm attached to the motor frame was arranged with an extension to enable the dynamometer to be calibrated using deadweights, a small knife edge being provided for the weight hook. To eliminate drag on the carcase, all electrical connections were made to the motor through mercury pots.

With certain types of dynamometers, the load indicated is proportional to the displacement of the torque arm from a zero position. On such machines careful calibration is needed to eliminate secondary effects

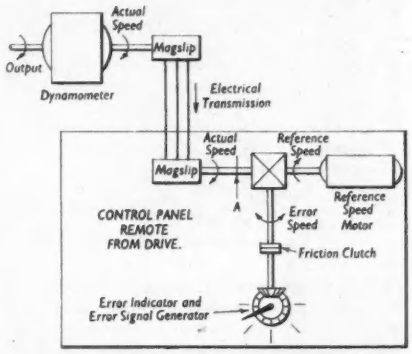

Fig. 7—The basis of the speed control system; the speed is compared with that of a reference speed motor

harmful to the accuracy of the dynamometer, such as the change in the centre of gravity of the dynamometer carcase with change of load, and the deflection of the electrical leads to the dynamometer. If mercury pots are used in place of flexible leads, they should be so arranged that the buoyancy of the mercury does not affect the accuracy. These effects are reduced to a minimum with the null-reading type of dynamometer described in this paper.

The armature was supplied from a d.c. generator. The supply to one-half of the

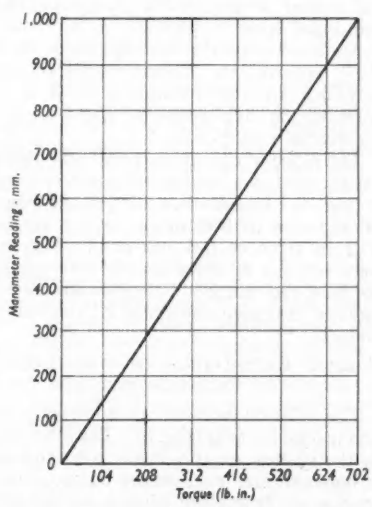

Fig. 8—Torque calibration curve

split field came from the d.c. mains and the other half was fed from a thyratron amplifier in the speed-control unit.

Speed-Control Unit

The need for a speed-control unit was demonstrated when the assembled dynamometer was run with and without speed control. With speed control the manometer reading was steady, but without speed control the reading varied with changes in speed. The manometer fluctuated in synchronism with the differential indicator in the speed-control unit. For the kind of work for which this dynamometer was intended, the repeatability of a speed setting was essential.

A commercial speed control was therefore

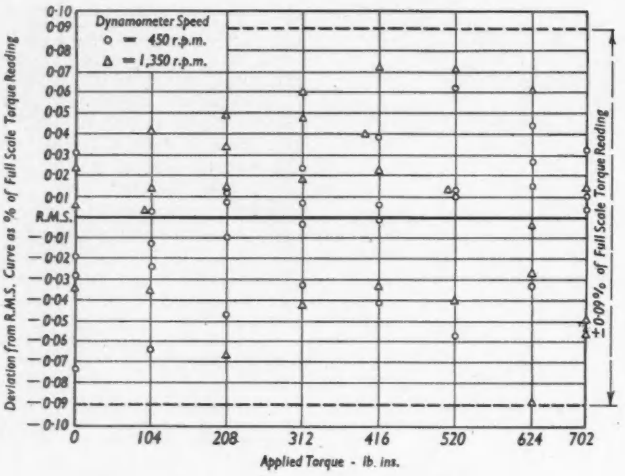

Fig. 9—Typical dynamometer torque calibration record

chosen which enabled a speed to be set and automatically maintained within close limits.[4] The basis of this system is shown in Fig. 7. The "reference speed" motor is a synchronous motor operated from a supply whose frequency is accurately fixed. In the basic system this frequency is determined by a tuning fork and a 30W amplifier provides the power for the synchronous motor.

When the dynamometer shaft is running at exactly the same speed as the "reference" motor, the output shaft from the differential connected between the two motors is stationary. Any small departure of the dynamometer from the correct speed causes a slow rotation of the output shaft from the differential; the direction of rotation indicates whether the speed is high or low. A friction clutch between the differential and the error-output shaft prevents damage to the differential which would be caused by a prolonged error in speed.

An electrical system, operated by the shaft, controls the output of the thyratron amplifier to the dynamometer field and corrects the dynamometer speed until the differential is stationary.

The range of operating speeds was obtained by interposing a mechanical gearbox at point *A* (Fig. 7). This gearbox allowed the selection of any one of 900 ratios over a range of 10/1 in steps of 0·1 per cent. The ratios were selected by three decade dials arranged so that the number selected on the dials directly indicated the speed of the dynamometer.

Torque Calibration of the Complete Dynamometer

The relation between manometer reading and torque is linear (Fig. 8). The inaccuracies of the system are too small to be shown on a conventional calibration curve, and the results are therefore shown as deviations from the R.M.S. value of a number of static calibrations (Fig. 9). These results were obtained over the course of a working day with the dynamometer and the torque measuring gear running continuously. The greatest variation from the R.M.S. value, based on a series of static calibrations, represented an accuracy of $\pm 0{\cdot}09$ per cent at full scale of the dynamometer.

It is customary on most dynamometers of this kind either to establish calibration curves at different speeds for eliminating the effect of windage on the torque reading or to use some scheme of windage elimination on the dynamometer itself. When the work was first started, it was fully intended to fit windage eliminators, but, as can be seen from the final calibration runs in Fig. 9, they were not necessary.

When working for long periods continuously, slight drifts in zero readings were found to coincide with changes in temperature of the oil in the torque weighing system. An explanation of this effect can be found in the leakage caused by deficiencies in manufacture of the torque weighing cylinder, and the effect of temperature on the mercury column. The specified clearance between the piston and the sleeve was 0·0005in, whereas the manufactured clearance became 0·0025in. Nevertheless, even with this increased clearance the measuring gear met the requirements. The total sustaining load of the piston is the product of the working pressure and the effective area, plus the shear associated with the leakage between the pressure and the exhaust ports along the valve boundary. Thus for a constant load on the piston, any alteration in the leakage rate affects the proportion between the two components.

Even though the error was within the specified limits of accuracy, steps are being taken to reduce it. These include a new piston and cylinder with the correct working clearance and a reduction of the temperature range of the working fluid by altering the by-pass arrangements at the pump. A torque unit for measurements greater than 1600 lb-in is also being developed.

Acknowledgment

The work described has been carried out as part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. The paper is published by permission of the Director of Mechanical Engineering Research.

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Hard Metal Facing of Bandsaw Teeth.—A new publication of Deloro Stellite, Ltd., Highlands Road, Birmingham, describes a process which has been developed by the firm for depositing the hard abrasive resistant alloy, "Stellite," on bandsaw teeth. In this process, each tooth of the saw is swaged to produce the usual tooth form with a dimple, and the teeth are side-dressed. A deposit of "Stellite" is then applied in each tooth dimple, and after the teeth have been tempered, they are ground in the usual way. It is stated that saws so tipped have a longer working life than untipped saws, and they can be reground up to ten times before refacing with hard metal is again necessary.

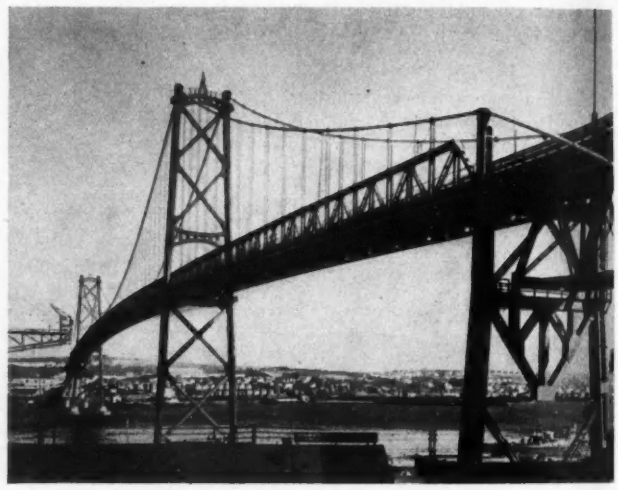
Canadian Suspension Bridge

A suspension bridge with a main span of almost 1450ft has recently been completed in Eastern Canada. The bridge is known as the Angus L. MacDonald Bridge, and gives a highway connection between the City of Halifax and the town of Dartmouth, in Nova Scotia. It was opened on April 2nd, after three years of constructional work, which, we are informed, constituted the largest bridge building project in Eastern Canada for a quarter of a century. The leading dimensions of the bridge are given in the accompanying table, and its general design is shown in the illustration.

Main Statistics of the Angus L. MacDonald Bridge

Overall length, abutment to abutment	4410ft
Length of main span between towers	1447ft 2in
Height of towers	309ft
Minimum clearance under main span	165ft
Total weight of steel in bridge	8227 tons
Length of main cables	3140ft
Distance apart of main cables	40ft
Sag of main cables	133—6in
Diameter of each of main cable	13·5in
Number of strands in each cable	61
Diameter of each individual strand	1⅛in
Width of roadway	27ft
Width of sidewalk	5ft
Cost of bridge, approximately, dollars	10,750,000

The first Halifax harbour bridge, a wooden structure with a steel swing span 640ft in length, was swept away by a storm in 1891. The present bridge is stated to be the second largest suspension bridge in the British Commonwealth, being exceeded in size by the Lions Gate Bridge in Vancouver, which it closely resembles. The Halifax-Dartmouth Bridge has a total length, including approaches, of 5290ft compared with 5978ft for the Lions Gate, and the central span at Halifax is 1447ft in length against 1550ft for Lions Gate.



The Angus L. MacDonald Bridge, as seen from the Halifax side of the harbour. It has an overall length, including approaches, of 5290ft

The bridge has a 27ft roadway and a 5ft pavement. It also carries a duct for power and telephone cables, and inspection walks, and there is provision for it to carry a 30in water main from the Dartmouth side of the habour when the City of Halifax outgrows its existing water supplies. There is often fog in Halifax harbour at certain seasons, so the bridge has sodium vapour lighting. Each of the three suspended spans has a "travelling bridge," which can be moved along beneath the span for inspection and maintenance.

The consulting engineer for the project was Dr. P. L. Pratley, of Montreal, with Mr. C. A. E. Fowler as associate engineer. The principal contractor for the superstructure was the Dominion Bridge Company, Ltd.; this firm was responsible for the fabrication and erection of the steel, but six other firms contributed to the fabrication of the structural steel components as sub-contractors.

Terminal Buildings at London Airport

(*Continued from page 461, April 1st*)

No. II—RADAR INSTALLATIONS

Certain air terminal buildings at London Airport are being commissioned this month ; they include the control tower in which is based an unusually comprehensive system of surveillance and navigational aids. Here we give a brief description of some of the radar equipment, namely, the long range and medium range surveillance sets, the height-finding radar and the millimetric radar for indicating movement of aircraft on the ground.

Southern Air Traffic Control Centre

THE new air traffic control centre for Southern England, which has been built at London Airport, will replace the air traffic control centre at Uxbridge, Middlesex, which was separated from the long-range radar unit at London Airport by 5 miles of telephone wires. The main advantage of the new centre is that for the first time the air traffic controllers will work directly alongside the radar unit.

The heart of the new centre consists of a control room 60ft by 50ft with a " service space " of the same size immediately below it. Only those items of radio and radar equipment required by the controlling staff are in the control room itself—the only radar equipments to be seen, for instance, are desk-mounted units. Associated

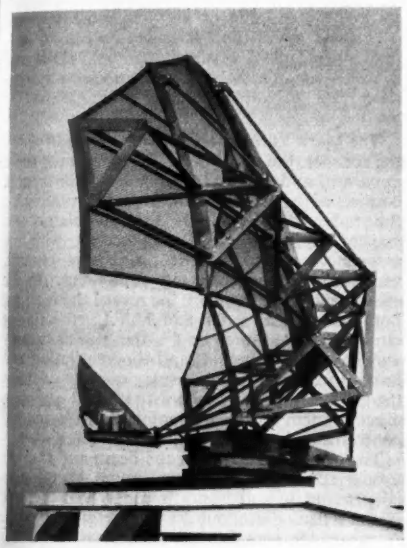


Fig. 1—The aerial of the " S232 " set is a horn-fed parabolic reflector with a horizontal beam-width of 3½ deg. It rotates at 10 r.p.m. on the roof of a concrete building which houses the transmitter and receiver

equipment has been placed immediately below or in nearby equipment rooms, and is easily reached for maintenance without disturbing the operating staff. Special attention has been given in the control room to acoustics, air conditioning and lighting. The problem of combining ordinary room lighting with the prevention of glare on the radar screens has been solved by using three-colour lighting in the ceiling and special amber screens over the radar tubes. Groups of three fluorescent tubes of different colours—blue, green and red—give a mixed light that looks white. The special screens over the radar tubes allow only amber light to pass through ; in this way the yellow radar blips can be seen clearly against a black background as long as the relatively bright room lighting is deficient in yellow.

Radar Installations

The radar installations at London Airport fall into five main categories, covering long-range (up to 120 miles) surveillance radar installations, a shorter-range installation, working up to 60 miles range, height finding, G.C.A. (ground control approach), landing equipment, and finally an aircraft surface movement indicator. Some of these installations are described below.

The controllers use long and short-range radars, which enable them to see aircraft on the screen immediately after take-off and to follow them out up to 100 miles ; inbound aircraft are similarly treated. Radar used in this way enables separation between aircraft to be reduced with safety so that more traffic can be handled in confined air spaces. Radar can also be used to assist a pilot where navigation may be in error, to give warnings of other aircraft which may present a hazard and to route aircraft around unfavourable weather. In cases of doubt or where pilots have not reported their altitude or are not in communication with the centre, the controller is able to get an appropriate altitude from a radar height finder. At the Southern Air Traffic Control Centre there is at present one height finder, but two more will be installed.

Long-Range Surveillance Radar

An airfield control radar, type " S232," has been developed by Marconi's Wireless Telegraph Company, Ltd., for long-range surveillance and for close control of aircraft within the airport terminal area. An early development version of this equipment has been in operational use for some time, and from it has been evolved the new " S232 " set, which is to be installed at London Airport in the near future.

Three points about the " S232 " equipment are of particular interest. The first is that it operates in 50cm (500–610 Mc/s) band with the object of minimising the effects of rain and cloud. The second is the introduction of an improved

Brief Specification of Marconi " S232 " Radar

Transmitter and receiver :	
Radio frequency	500–610 Mc/s crystal controlled (eleven spot frequencies are provided)
Peak power output	50–60kW
Pulse recurrence frequency	500–800 p.p.s. crystal controlled
Pulse length	2 or 4 microseconds (remotely controlled)
Receiver noise factor	8–10 db approximately
Receiver bandwidth (overall)	500 kc/s at 3 db down
Receiver intermediate frequency	45 Mc/s
Permanent echo suppression	At least 46 db, up to maximum range
Aerial System :	
Horizontal beam width ...	3½ deg. at 3 db down approximately
Vertical coverage	20 deg. approximately
Polarisation	Horizontal
Tilt adjustment	−1 deg. to +10 deg. to the horizontal
Length of reflector	29ft
Height of reflector	10ft
Maximum speed of rotation	10 r.p.m. servo-controlled
P.P.I. displays :	
P.P.I. time-base ranges ...	0–20 to 0–120 nautical miles continuously variable
Range markers	5 and 10 nautical mile intervals
Additional P.P.I. facilities ...	Off-centre, video map input, short time-constant ; electronic azicator for height finder if required
Power requirements :	400V, 3 phase, 50 cycle, 12kVA (approx.)

M.T.I. (moving target indicator) system for differentiating between fixed and moving objects, cancelling the former from the viewing screen and leaving a clear field for the observation of aircraft. The " S232 " is the only known airfield radar set that uses a crystal-controlled fundamental frequency to produce both the reference signal and the frequency stabilisation of the transmitted and received signals. This device is stated to give a permanent echo suppression better than 46 db, compared with a typical figure of 30 db for the so-called " coho-stalo " systems which use a free-running transmitter

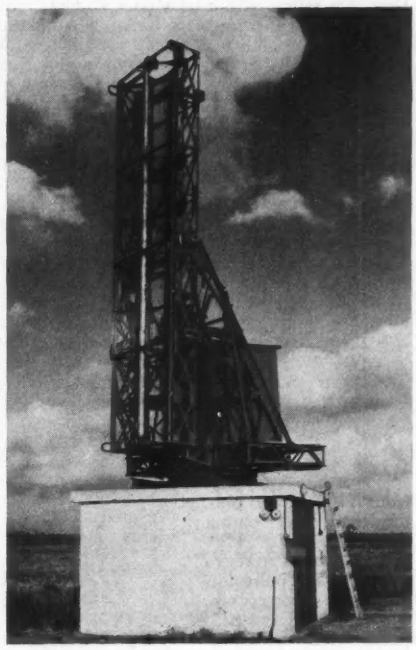


Fig. 2—The aerial system of the " S13 " height-finder is a waveguide-fed paraboloid which oscillates ten times per minute about a horizontal axis and is rotated at 10 r.p.m. about a vertical axis

and various means of achieving coherence between the received echo signal and a reference signal. Because of the resulting reduction in permanent echoes this radar set can locate an aircraft at any range between about ¼ mile and 100 miles. Since up to eight P.P.I. (plan position indicator) displays can normally be used with one aerial head, the set can fulfil long and short-range functions simultaneously.

The third point is that the use of crystal control enables the set to be switched on and operated without requiring any tuning adjustment. Similarly, the M.T.I. system is stabilised and ready for immediate use.

The " S232 " radar installation can be divided broadly into two parts : one is known as the aerial head and it consists of a small concrete building containing the transmitter, the receiver, and the drive for the rotating aerial and reflector assembly, which is mounted on the roof as indicated in Fig. 1 ; the other part includes the display equipment and auxiliaries and is installed in the operations building.

The aerial system, consisting of a parabolic reflector energised by an off-set horn, is designed to give a narrow horizontal beam width, together with a very small loss of power in side lobes. The vertical cover is approximately 20 deg. A thermostatically-controlled heating element is incorporated into the back of the horn for de-icing purposes. The reflector is an aluminium mesh supported on a light alloy framework, the whole structure being pivoted so that preset tilt may be applied in the vertical plane from −1 deg. to +10 deg. to the horizontal, the horn remaining at the reflector focal point at all times during tilt. By this tilting facility, the main beam may be raised in the vertical plane to alter the vertical cover. The horizontal beam width is approximately 3½ deg. at 3 db down (measured in one direction only) and depends on the radio frequency employed.

Control of the aerial turning mechanism is exercised from the radar office which houses the main display consoles, and provides the following facilities : continuous rotation of the aerial in either direction, at speeds from ¼ to 10 r.p.m. ; sweeping in a reciprocating cycle, over an arc of from 10 deg. to 60 deg. either side of any preselected mean bearing, at speeds of 1/17 to 2½ r.p.m. ; and manual position-laying by means of coarse and fine controls at a speed of up to 10 r.p.m.

In the transmitter a frequency of 5·625 Mc/s is generated by a crystal-controlled reference oscillator and fed to the transmitter mixer unit.

Here it is mixed with a 60 Mc/s c.w. signal and the resultant 65·625 Mc/s signal is amplified and passed to the first doubler stage. There are two further doubler stages, then an intermediate amplifier and, finally, the power amplifier. The three doublers and the two power amplifiers are each pulse-modulated, the pulse duration being progressively narrower for each modulated stage to ensure a rapid build-up of r.f. amplitude at the start of each transmitted pulse, so that the time interval between the leading edges of successive pulses is very accurately maintained. The 60 Mc/s signal referred to above is derived from a separate unit embodied in the receiver, and consists of a crystal oscillator and a number of frequency multiplying stages. The crystal frequency is nominally 10 Mc/s, but up to eleven crystals may be selected to enable the transmitter to cover a frequency range of 500–610 Mc/s. The crystal frequency is multiplied six times to provide the 60 Mc/s signal to the transmitter, which, when mixed with the 5·625 Mc/s signal, is then multiplied up to the final radiated frequency. Assuming a fundamental frequency of 10 Mc/s from this oscillator unit, the transmitter output frequency is 525 Mc/s with an output power of 50–60kW at a pulse duration of 4 microseconds. The final transmitted pulse length can be set either to 2½ or 4 microseconds, either by local or remote control. A P.R.F. (pulse recurrence frequency) of 500–800 p.p.s. (crystal-controlled) is used.

In the receiver the echoes reflected from the target are picked up by the aerial system and pass, via a T/R switch unit, to the receiver, the first stage of which is a grounded grid coaxial triode r.f. amplifier. This stage is followed by a triode mixer, where the 525 Mc/s target signal is mixed with a local oscillator signal of 480 Mc/s (the latter also being derived from a frequency-multiplication of the 10 Mc/s crystal oscillator described above). The resultant 45 Mc/s signal is fed into an i.f. head amplifier, the output of which is taken by coaxial cable to the radar distribution unit in the operations building. Part of these i.f. signals are also fed via another amplifier in the receiver unit to a 6in "A" scan display monitor unit.

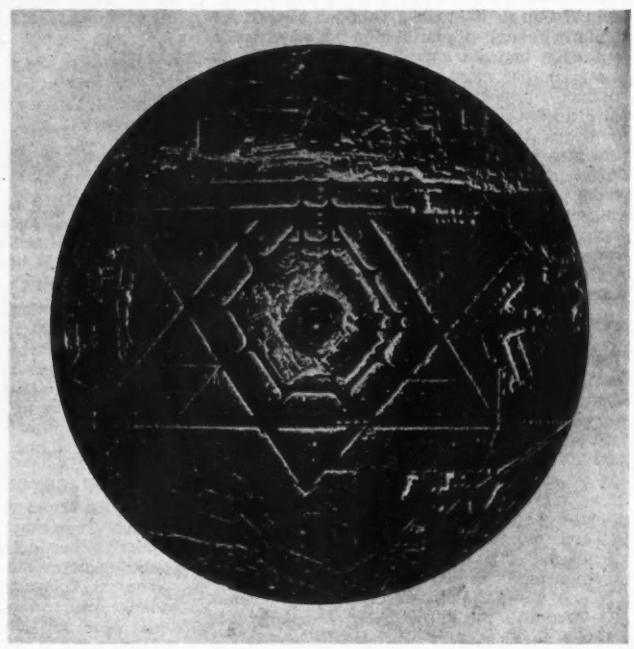


Fig. 3—Display showing movement of aircraft on upper and lower runways. Four positions of an aircraft produced on successive rotations of the scanner can be seen near the centre of the lower runway

The radar display equipment in the operations building consists of two main parts. The first part is the radar distribution unit which receives the radar signals from the aerial head, converts them to video signals and sends them, with locally-generated calibration marks, to the P.P.I. display units which make up the other half of the display equipment. The P.P.I. display is produced on a flat-faced fluoride cathode-ray tube with moving-coil operation, and the facilities that it provides include off-centring, provision for multiple-head working, variable short-time constant and electronic azication for use with height-finding radar.

The radar distribution unit also contains the cancellation circuits for the moving-target indicator system. Briefly, their operation is as follows: the crystal-controlled 5·625 Mc/s reference oscillator provides the fundamental stabilising control for the whole equipment. One output at this frequency is fed to the transmitter, as previously described, while a second output is frequency-multiplied eight times (45 Mc/s) and fed to a "Homodyne" detector. The received (echo) signals, after conversion to an intermediate frequency of 45 Mc/s in the receiver, are amplified and also passed to the "Homodyne." This detector is therefore fed with 45 Mc/s from two sources, and its output will be proportional to the relative phases of the two signals. The phase of the locally produced oscillation will be fixed, while the received signal will be out-of-phase with it by an amount depending on the position of the target. It follows, therefore, that the received signal from a fixed object will always produce the same phase difference with every pulse, but a moving object will produce a phase difference which varies in amount with every pulse. To determine whether an object is moving or not it is only necessary to compare the "Homodyne" output produced by one pulse with that produced by the next pulse. A water delay line is used to achieve this discrimination, in the following way.

The output from the "Homodyne" detector (virtually video frequency) is used to modulate a 10 Mc/s crystal-controlled oscillator. The modulated oscillations are fed to a crystal which is mounted at the near end of a water-filled tube. They are converted by the crystal to mechanical oscillations at supersonic frequency (10 Mc/s) and as such travel along the tube, being reflected into another tube at the far end. This second tube lies parallel to the first, and the mechanical oscillations travel down it until they meet a crystal at the far end which reconstitutes them to electrical oscillations. The length of the tubes is so adjusted that the time taken for a pulse to travel from one crystal to the other is exactly equal to the time-interval between two pulses of the radar transmitter. The temperature of the water in the tubes is kept at 72 deg. Cent. by thermostat control. The output of the delay line is demodulated, and after inversion is mixed with demodulated signals which have not been delayed. Identical signals are thereby cancelled out; only those signals whose phases have changed between successive pulses appearing at the output of the mixer. These are rectified and fed through a video amplifier to three separate cathode followers, thence by coaxial cable to the P.P.I. consoles. Uncancelled signals are also fed to the consoles so that the operators may select either type of signal at will.

Short-Range Surveillance Radar

To give radar coverage of London Airport and its approaches up to a range of 60 nautical miles, a Cossor Airfield Control Radar, Mark VI, is being installed. Within this range the radar gives plan position indication on any number of display consoles up to three. On each of these displays any one of four range scales (10, 20, 40 or 60 nautical miles) can be selected independently and the centre of rotation can be offset from the centre of the tube by any amount up to the radius of the tube. Echo clutter from fixed objects is suppressed from the display by M.T.I. circuits, leaving only the moving targets over the full range of the set.

Because fixed reference marks are desirable on a surveillance radar (especially with M.T.I.), a system of video mapping is incorporated so that any desired diagram map can be introduced on the display to appear in true relationship, whatever range or offset is selected. To facilitate identification of responses, special circuits are included which accept output signals from the airfield automatic radio direction-finding system, and superimpose a radial trace on the display to indicate the particular radar response of the aircraft that is making the radio transmission. All the main electronic units are externally sealed and a built-in air circulation system continuously cools and dries the internal air. Special overheating auto-alarm devices are provided; in the event of fire the power supply is switched off and fire extinguishers are brought into action, while aural and visual warning are given. Metering and waveform monitoring facilities are incorporated as well as frequency and power output measuring instruments, to ensure correct setting up and operation with the least difficulty.

Technical particulars of the equipment are given in the accompanying tabular summary:

Main Particulars of Cossor Mark VI Airfield Control Radar

Frequency	2960–2980 Mc/s
Peak power	450kW
P.R.F.	850 per second
Pulse width	1 micro second approx.
Maximum range scale	60 nautical miles
Accuracy:	
Azimuth	± 1 deg.
Range	± 1 per cent or ± ¼ mile whichever greater
Discrimination:	
Azimuth	2 deg. separation
Range	¼ mile separation
Scanner rotation	10 or 15 r.p.m.

The Mark VI radar consists of four main parts: the scanner, the radar head, the equipment room apparatus and the display consoles. The scanner consists of the aerial and the drive for rotating it; the radar head contains the modulator and transmitter and part of the receiver with the associated power supplies and the control, ventilation and monitoring equipment. In the equipment room there are the rest of the receiver, both for normal radar and M.T.I., the timing circuits, video mapping, the power supply and control equipment, and the ventilation and monitoring gear. Each display console contains the P.P.I. cathode-ray tube with its e.h.t. supplies, together with a sweep amplifier, range marker generator and a special cathode-ray d.f. unit.

To avoid obstruction of the beam and thereby to give coverage at minimum range, the scanner is normally mounted on a tower so that the pole of the reflector is about 20ft above ground level. A waveguide connects the scanner to the radar head.

The reflector is an oblique section of a paraboloid, the pole being nearer to the bottom of the section. It is made of moulded plastics material, the reflecting surface being designed to withstand distort by heat or cold, water absorption or wind forces. The surface is metal sprayed to render it conducting, and does not discriminate against any particular plane of polarisation, so that circular polarising devices for anti-rain clutter may be fitted if required. The feed is via a waveguide rotating joint to an array of twelve horns, the distribution of power being such as to give a vertical coverage of the cosecant type. The mica windows of the horns are electrically heated for de-icing purposes by means of inconel elements, the necessary power being delivered via sliprings and a step-down transformer.

An all-welded structure of solid drawn steel tube carries the reflector and feed.

An 8 h.p. electric motor with star-delta starting drives the turntable through a gearbox, giving alternative speeds of rotation. High and low-speed "Telesyns" are incorporated which provide the necessary information for a scanner following unit in the equipment room to follow the rotation with great accuracy. A North-marker switch is provided, and a red obstruction lamp.

Additional aerial gear, such as secondary radar

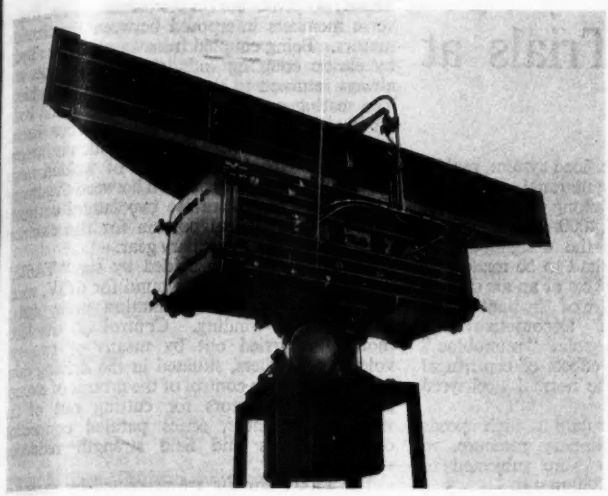


Fig. 4—Scanner and radar head of airfield surface movement indicator at London Airport. The input arrangements to the transmitting and receiving zones of the scanner can be seen

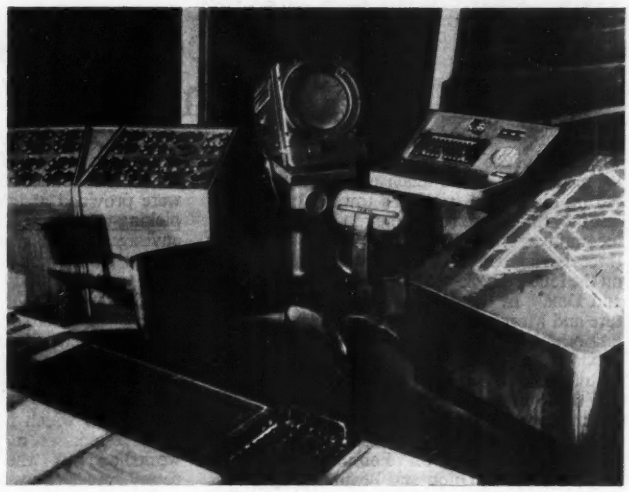


Fig. 5—Part of the air traffic control room at London Airport showing the surface movement radar display unit. The mimic diagram desk on the right is a separate equipment

or I.F.F. can be fitted and provision is made for the necessary extra sliprings and brushgear.

The radar head consists of apparatus contained in four steel cubicles. Three of these cubicles (r.f. modulator and power supply) are mounted on rollers running in floor rails. They can be released from the air trunking and electrical connections at the back and drawn forward to give access for maintenance. The fourth cubicle contains the control apparatus and it is fixed.

The equipment room contains five fixed cubicles from which the electronic equipment can be withdrawn whilst still functioning, on to a special servicing tray which fits into position on any cubicle.

Radar Heightfinder

Information about the height of aircraft flying within the range of London radar will be given to the controllers by a Marconi " S13 " radar heightfinder used in conjunction with other radars. The " S13 " set is a high-power, long-range set operating in the 10cm band.

The principle upon which this set operates is that the radio energy from the aerial system is transmitted in the form of a narrow beam 1 deg. wide vertically and approximately 5 deg. wide horizontally. This beam is tilted up and down vertically ten times per minute and thus scans an area of sky 5 deg. wide. When an aircraft has been located on the plan position (P.P.I.) display associated with one of the azimuth search radars, the aerial system of the heightfinder is rotated by remote control so that the aircraft is scanned by the radiated beam. When the beam crosses the aircraft the received echo causes a spot of light to appear on the cathode-ray tube display at the position appropriate to its altitude, and the necessary height information is then passed by the height-reading operator to the radar controller at the P.P.I.

Brief Specification of Marconi " S13 " Heightfinder

Frequency	3000 Mc/s (nominal)
Pulse length	0·6 or 1·9 microseconds
Pulse recurrence frequency	500 p.p.s or 250 p.p.s
Peak power output	500kW (approx.)
Receiver noise factor	9–10·5 db
Receiver IF	45 Mc/s
Receiver band width	3·5 Mc/s or 1 Mc/s
Maximum range	150 nautical miles (270 km) (dependent upon target size)
Elevation	−1 deg. to + 25 deg.
Accuracy	±500ft (150m) at 50 nautical miles range (approx.)
Beam width :	
Vertical	1 deg.
Horizontal	4·5 deg. (for 6 db attenuation on either side)
Power consumption	12kW (approx.)
Power supplies	230V, 50 c/s, three phase (delta connected), a.c. 230V, 50 c/s, single phase, a.c.

The heightfinder consists of an aerial head comprising an aerial system with its associated turning equipment together with a modulator, transmitter and receiver. The aerial system, which is mounted on the roof of a concrete building (Fig. 2) can be rotated horizontally at speeds up to 10 r.p.m., while the reflector and waveguide feed tilt ten times per minute in a vertical plane. Both transmitter and receiver are installed in the concrete building and the signals are fed by cables to the display equipment in the operations building.

The set operates on a wavelength of 10cm, at which ground reflections are not troublesome. The high-power transmitter is modulated by a 7kV pulse of short duration (0·6 or 1·9 microseconds) produced by a modulator unit with a pulse recurrence frequency of either 500 or 250 per second (nominal). Received signals are passed at video frequency to a display console, situated in the operations room, which employs an elevation-scan type of display to indicate aircraft heights.

The aerial system consists of a slotted waveguide positioned along the focal line of a vertical paraboloid reflector. Radiation takes place from the slots, which are so arranged that a narrow beam is produced in the plane of the waveguide. A "Perspex" cover protects the slotted section. Condensation is prevented by means of an air drier system. The reflector is made to oscillate in the vertical plane such that the radiated beam scans a vertical angle between −1 deg. and +25 deg. to the horizontal, ten times per minute. An automatic switch ensures that when the motor is switched off the reflector always comes to rest at its lowest position.

A direct presentation of the range and height of the aircraft is given in the form of an elevation-scan display on the cathode-ray tube. The target is indicated by a bright spot on the tube face, with a long after-glow. The trace pivots about a point at the bottom left-hand side of the tube face and tilts up and down in synchronism with the aerial system. The height of the target can be read off directly from the constant-height curves marked on the face of the tube.

Radar for Airfield Surface Movement Indication

As mentioned last week, ground movement control will be facilitated (particularly when visibility is bad) by the use of a millimetric radar set, which is known as an airfield surface movement indicator (A.S.M.I.). This equipment operates in the 8mm waveband (34,000 Mc/s) which enables it to produce a P.P.I. display image of the airport with a clarity and detail that would be beyond the scope of equipments using the conventional 10cm and 3cm wavebands. On this display (Fig. 3) all traffic, whether moving or stationary, on the runways or perimeter can be plotted. London Airport is believed to be the first airport in the world to be equipped with millimetric radar as a permanent installation for aircraft surface movement indication. The equipment is known as Q-band radar, and it was designed and made by Decca Radar, Ltd., 1-3, Brixton Road, London, S.W.9.

The scanner (Fig. 4), consists of a rotating double " cheese " system, with separate zones for transmitting and receiving; it is mounted on a short mast at the top of the 120ft control tower, whence it commands an uninterrupted radar view of all the runways and associated taxi tracks. There are two 12in diameter display units in the main air traffic control room; one display (Fig. 5) is for use by a ground movements control officer, who shares it with a lighting and route control officer; the other display is for use in conjunction with the standard navigational aids for monitoring take-offs and checking out-bound traffic. It is proposed to extend the A.S.M.I. facility at a later date by installing a third display in the approach control room, to work in conjunction with the G.C.A. and other landing aids.

Immediately below the scanner (Fig. 4) there is a cast housing, which contains the radar head, consisting of a magnetron, klystron and power pack and a modulator, mixer and pre-amplifier. The scanner and radar head are rotated as a single unit at 20/24 r.p.m. by a geared motor.

Main Particulars of Millimetric Radar for Airfield Surface Movement Indication

Frequency band	Within 8·69 mm–8·83mm
Aerial system :	
Reflectors	Double 6ft " cheese "
Horizontal beam	About 23 min. } At half
Vertical beam	About 14 deg. } power points
Side lobes	On inner lobes about 20 db down on main beam; outer side lobe better than 26 db
Pulse characteristics :	
Pulse generator	Triggered hard-valve modulator
Peak power	12kW–14kW
Duration	0·05 microsecond
Recurrence	About 4000 per second
Range :	
Discrimination	About 30ft
Accuracy :	
Range marker	Within 2 per cent
Range rings	Within 1 per cent
Minimum range	Down to few yards
Scales	0·5 mile, 1 mile, 3 and 10 miles
Bearing :	
Discrimination	About 25 min, measured at 1500 yards
Accuracy	±0·5 deg.

The receiver, which contains the v.f. and i.f. amplifiers, is arranged for wall mounting and, since it contains no operational controls, it can be fitted in an out-of-the-way position. Both linear and logarithmic characteristics are embodied in the i.f. amplifiers and they can be switched into circuit remotely from the operational display. The logarithmic receiver, the anti-clutter circuits and the fast-time-constant, offer means of suppressing interference from rain and snow.

The display (Fig. 5) is produced on a 12in diameter fluoride cathode-ray tube, which has a long after-glow characteristic. A cowl is fitted to obtain optimum presentation of the display under high intensity room lighting conditions. In addition to the normal display controls, there are facilities for line/logarithmic i.f. switching, fast-time-constant, and anti-clutter control. A directly-calibrated range stroke marker is fitted. The bearing scale is illuminated and calibrated in degrees and the cursor is rotated manually.

Power for the radar set (about 2kW) is obtained from a motor alternator generating at 80V, 1000 c/s, with a voltage control panel.

(To be continued)

French Electric Locomotive Trials at 205 m.p.h.

SPEEDS of 205·6 m.p.h. are stated to have been reached by two French electric locomotives during high-speed trial runs towards the end of last month. These runs were made separately by locomotives " CC7107 " and " BB9004," hauling three-carriage trains of a total weight of 100 tons, on the 1500V d.c. electrified line between Bordeaux and Dax. In the 41-mile stretch between Facture and Morcenx there is a straight level section, Lainothe-Morcenx, of 21 miles, over which the maximum speed was attained.

Reference to locomotives of these two classes was made in a recent article in these columns.* We may recall that the " CC7107," built by the Société Alsthom, is of the same class as the " CC7121," which, on February 21, 1954, reached between Dijon and Beaune the previous world rail record speed of 151 m.p.h., also hauling three carriages. It is mounted on two bogies, each with three driving axles. The continuous rating is 4300 h.p. and the one-hour rating 4700 h.p. Locomotives of this class, of which there are sixty in service, haul the " Mistral " express daily between Paris and Lyon at an average speed of over 76 m.p.h., which is also a world record over that distance for a passenger train in regular service.

The " BB9004 " locomotive, built in 1953 for the same purpose by the Société de Matériel de Traction Electrique (a group of three firms, Le Creusot, Schneider-Westinghouse and Jeumont), is lighter and weighs only 81 tons. It is also slightly less powerful than the " CC7107," with a continuous rating of 4000 h.p. and a one-hour rating of 4400 h.p. It is the latest type of 1500V d.c. electric locomotive ordered by the French Railways for hauling trains at high speeds.

The main objects of these two record-breaking trials were to ascertain the capabilities of this new " BB9004 " locomotive, to compare it at very high speeds with the " CC7107," to test them both at a speed in excess of the previous record of 151 m.p.h., and to study the behaviour of the carriages, track and overhead contact wire at very high speeds. For this purpose the transmission system of both was modified so as to raise the gear ratio to achieve speeds in the neighbourhood of 185 m.p.h. On the basis that 4000 h.p. was sufficient for a speed of 151 m.p.h., it was calculated that over 10,000 h.p. would be required for 185 m.p.h. To reinforce the current-carrying capacity of the overhead system, mobile substations connected to the national grid system were provided at intervals along the line. The picking-up of a current of 4000A at the speeds envisaged made necessary the designing of a special pantograph. Tests had to be made in a wind tunnel to study the effects of an air current of 185 m.p.h. on the pressure of the pantograph against the traction wire. Locomotives and carriages were fitted with solid " monobloc " wheels so as to avoid the effects of centrifugal force and of braking on the normal steel-tyred wheel.

All parts which had to rotate at high speeds were tested, as a precautionary measure, in workshop pits where they were subjected to rotary speeds equivalent to 280 m.p.h.

For controlling the trial runs, a two-way radio link was provided between a control post and the driver's cab on the locomotives. The runs took place as scheduled on the morning of March 28th (locomotive " CC7107 ") and on the morning of the 29th (locomotive " BB9004 "). A speed of 185 m.p.h. was reached after travelling 13 miles. The two locomotives travelled at over 185 m.p.h. for 7½ miles and at over 199 m.p.h. for nearly 4 miles. The speed of 205·6 m.p.h. was maintained over nearly 1¼ miles. We learn that the maximum speed was specifically limited by the fact that it was necessary to enter the straight stretch at not more than 125 m.p.h. and to leave it at not more than 75 m.p.h. The power reached exceeded the estimated figure, and at the maximum speed the locomotives were using 12,000 h.p. Their stability as measured by accelerometers was very satisfactory.

Locomotive " CC7107 "

This locomotive (shown in our first illustration) is one of sixty built by the Société Alsthom and put into service since 1949 ; it is designed to haul heavy high-speed express trains and light trains at very high speeds. It is made up from a single body resting on two free bogies, each with three motored axles, the whole weight being available for adhesion. The main characteristics of this design are as follows : total weight in running order, 106 tons ; continuous rating (at 1500V), 4300 h.p. ; one-hour rating, 4700 h.p.

The bogie chassis is of tubular construction with welded plates. One innovation in this locomotive is that the body rests on each bogie through two oscillating pivots, with double articulation, and equipped with rubber cones. These two pivots act on the centres of two transverse members interposed between the traction motors. Being coupled transversely to the body by elastic coupling rods, these two pivots are always returned to their mean vertical position. The seating arrangements for holding the body on each bogie are completed by four lateral balancing members. The body, which is integral with the chassis, is made up of welded metal sheets. In the central portion between the driving cab at each end there are two lateral corridors and a closed central portion for the electrical equipment and the auxiliary gear.

Motive power is provided by six " TA621," six-pole traction motors wound for 675V, which are provided with commutation poles and a compensation winding. Control of the locomotive is carried out by means of two low voltage controllers, situated in the driving cabs, providing remote control of the groups of electro-pneumatic contactors for cutting out of the starting resistances, series parallel connection of the motors and field strength reduction stages.

The 1500V circuits are protected by means of an Alsthom " JRT " high-speed circuit breaker.

To facilitate inspection and maintenance, the various electrical equipment items have been assembled in groups, as follows : a central group comprising the starting resistances, the line contactors and starting contactors, the coupling switches and the various main relays ; and two motor groups, each including a reverser, isolating equipment and the contactors and shunting resistances for the three traction motors on each bogie.

These groups are easily detachable and may be removed from the locomotive through the roof. The connections to their low voltage circuits and to the control circuits are carried out by means of multiple couplers. Interlocks prevent access to the high voltage equipment except when the locomotive is isolated from the contact lines.

Locomotive " BB9004 "

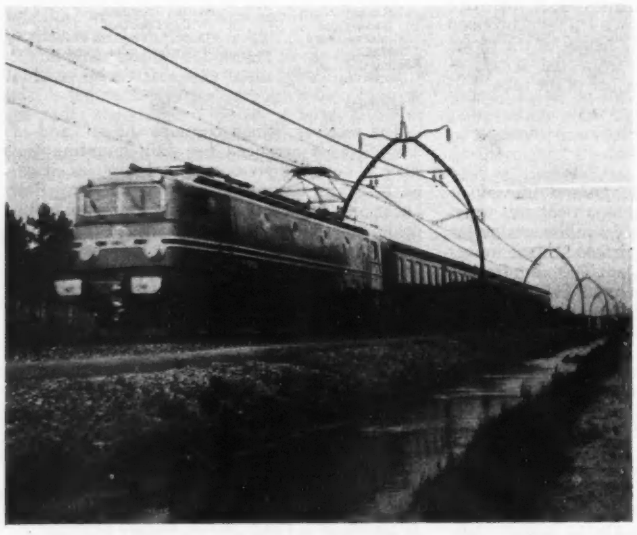
The prototype electric locomotive " BB9004 " was built in 1953 by the Société de Matériel de Traction Electrique, is entirely of French design and construction and presents few points of similarity with types such as the 2–D–2 and the CC locomotives hitherto built for the haulage of heavy passenger trains at high speeds. Novel methods were used for supporting the weight of the body on the bogies and transmitting the power of the motors to the driving wheels.†

It has total adhesion with a one-piece, all-welded body mounted on two bogies each of two axles

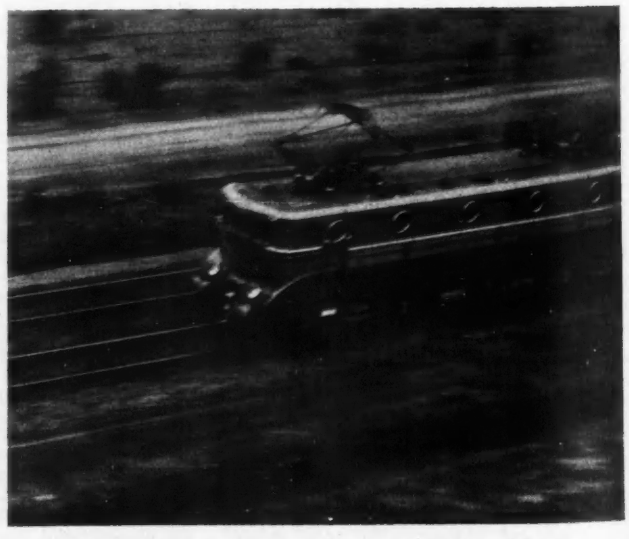
The four-pole, non-compensated traction motors built by Schneider-Westinghouse are

* " Improvements in Direct Current Traction in France," by B. K. Cooper. February 11, 1955.

† *Loc. cit.*



Test train hauled by locomotive CC7107 during speed trial on March 28th. The continuous rating is 4300 h.p. (106 tons all-up weight). At 205 m.p.h., the output developed was about 12,000 h.p.



Locomotive BB9004 during speed trial on March 29th. The continuous rating is 4320 h.p. (81 tons all-up weight) and about 12,000 h.p. was developed at 205 m.p.h.

entirely suspended at the centre of the bogie frames (there are no bogie pivots in the ordinary sense). They transmit their power to the axles by means of a cardan shaft coupled to one of the driving wheels. They can be coupled in series-parallel and in parallel. The locomotive has forty-two starting notches (twenty-three in series-parallel and nineteen in parallel), together with ten weak-field notches in each grouping, only five of which are running notches. There are twelve economical running notches with maximum field. Starting is effected by variation of resistances placed in series with the motors.

The principal characteristics are as follows :—

Length overall	53ft 6in
Length between bogie centres	30ft 7in
Length between axle centres	10ft 6in
Diameter of wheels	4ft 4in
Horsepower at 1500V :	
Continuous rating	4320
One-hour rating	4800

The all-welded bogie frames are supported by means of coil springs on two longitudinal equalising beams directly linked to the axle-boxes on the same side by means of large Silent-bloc mountings. Lateral movement of the axles is not controlled by the axleboxes, but by the transmission system which operates by means of a hollow cardan shaft surrounding the axle, provided with Silentblocs, the articulations on the axle allowing slight lateral movement with initial tension.

The traction motors, fixed side by side to the bogie frame, can be coupled by a toothed wheel meshing with the pinions ; the latter drive the resilient main gear wheel of the transmission system, which is mounted on a roller-bearing pivot, through an intermediate gear wheel. The whole gear trains run in longitudinal gear cases which are integral with the bogie frames.

The body is all-welded, but the upper side panels and the centre roof sections can be quickly dismantled so as to facilitate inspection and maintenance. The weight of the body is carried on the bogies through a bilateral pendulum type suspension system with laminated springs which minimise rolling, and with "anti-nosing" friction bolsters. Tractive effort is transmitted longitudinally to the body through traction drawbars, which can be dismantled, and which are mounted underneath the bogies so as to minimise "hunting." These drawbars are mounted on a shock-absorbing device which transfers exceptional tractive efforts on to thrust blocks mounted above the bogies.

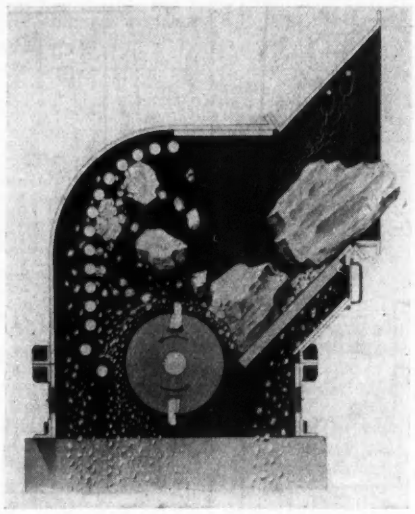
Inside the body between the driving cabs is a large central compartment housing the high-tension equipment and the auxiliaries with passageways each side. The high-tension equipment is interlocked to prevent access until the locomotive has been isolated from the traction current supply.

Impact Rock Breaking Machine

THE operation of a machine now being made by British Jeffrey-Diamond, Ltd., Wakefield, for reducing hard friable material from 36in down to 90 per cent below 1½in in one stage, can be seen in the illustration above. This rock buster, as it is known, is available in two sizes with capacities from 65 to 220 tons per hour and 90 to 300 tons per hour.

The machine has a heavy steel plate frame in the lower part of which is a balanced rotor built up of laminated sections of 5in thick slab steel discs. Manganese steel hammers are securely fastened on the rotor, the shaft of which is carried on heavy-duty anti-friction bearings.

Material fed into the crusher passes a curtain of chains and gravitates down a grizzly through which is removed a large portion of the fines. At the bottom of the grizzly the larger blocks of material come into contact with the rotor hammers, which break off pieces and fling them against rods at the top of the crusher with sufficient force to reduce the size still further. Pieces of rock to the size required pass through the spaces between the rods across the top and front of the machine and fall to the bottom or discharge point. Larger pieces of material which require further reduction rebound back towards the rotor and are broken down by other pieces thrown by the rotor and moving in the opposite



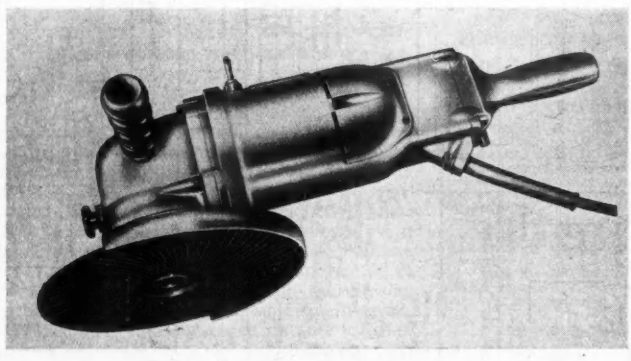
Operation of rock breaker designed to reduce 36in material to less than 1½in in one stage

direction. Final reduction of large pieces takes place between cast manganese steel rings, carried on two shafts arranged to form a shelf across the width of the machine, and the periphery of the impact hammers on the rotor.

It will be appreciated that the size of the final product can be controlled by any or all of three adjustments—the speed of the rotor, the spacing of the rods, or by the setting of the shelf formed by the shafts carrying the rings in front of the rotor. The distance between these shafts and the rotor is adjusted by a large lever on the outside of the machine. At each of its settings the lever is held by a shear pin which protects the mechanism from damage in the event of tramp iron entering with the rock. The shearing of this pin as a result of undue loading opens the gap between the shelf and the rotor to release the iron into the discharge.

Portable Electric Grinders for Disc Wheels

A PHOTOGRAPH we reproduce below shows a new portable electric grinding machine made by Wolf Electric Tools, Ltd., Hanger Lane, London, W.5, for use with depressed centre, reinforced grinding disc wheels. This form of resin-bonded wheel is designed for metal trimming, cutting-off, fettling, &c., and the edge only is used. The new machines are made in two sizes to take 7in and 9in diameter disc wheels, and each model is fitted with a universal motor having a continuous rating of 1·5 b.h.p. The balanced armatures of the motors as well as the gears and spindles are mounted on ball and needle roller bearings, which are double sealed to retain grease and prevent the ingress of dust.



Portable electric grinder for 7in disc wheels having a spindle speed of 8000 r.p.m.

The 7in machine has a spindle speed of 8000 r.p.m. and the 9in machine a spindle speed of 6000 r.p.m., which are the requisite operating speeds to give the maximum disc performance and disc life. Discs from $\frac{3}{16}$in to $\frac{1}{4}$in thick can be mounted in the machines, although the standard disc fitted by the makers is ¼in thick and is considered to suit all general requirements when working with steel, iron and non-ferrous metals. To widen the range of application of the machines high-speed backing pads can be supplied for use with silicon carbide and aluminous oxide fibre backed sanding discs.

A spring-loaded spindle locking plunger can be used when mounting discs and a pressed steel guard extending round half of the circumference protects the operator.

Behaviour of 0·276in Diameter Wire in Pretensioned Concrete Beams

THE advantage of using fewer wires in making the larger pretensioned, prestressed beams induced the civil engineer's department, British Railways, Eastern Region, to carry out tests to investigate the applicability of smooth wire of 0·276in diameter for pretensioning. A first series of tests was carried out in the summer of 1952, as reported briefly in the supplement of CII2, "The Use of High-Strength steel in Ordinary Reinforced and Prestressed Concrete Beams," which appeared in the final report (1953) of the Fourth Congress, Cambridge, of the International Association for Bridge and Structural Engineering. These static tests of 1952 already proved the suitability from the point of view of bend, of smooth 0·276in wire for pretensioning, with high-strength concrete. In 1953–54 further static and fatigue tests were carried out.

Whilst static tests showed already the suitability of pretensioned 0·276in bonded wire, fatigue tests carried out in the summer of 1954 indicated the extraordinary resistance of such prestressed beams, the Eastern Region states. All the beams had a length of 15ft 6in and to two beams 1,000,000 repetitions of loading were applied between loads corresponding to a compressive stress of 10 lb per square inch and a nominal tensile stress of 600 lb per square inch. Previously the beams were deliberately loaded until cracks had developed. On removal of the load the fine cracks became invisible after completion of the fatigue tests. In subsequent static tests the wires fractured under the maximum calculated load. In one further test 1,000,000 repetitions were carried out as before, but in a non-cracked state. Afterwards, nearly 9,000,000 repetitions were applied in a cracked state. The lower limit loading corresponded to a compressive stress of 270 lb per square inch, and the upper limit to a nominal tensile stress gradually increasing from 650 lb to 1270 lb per square inch when the load corresponded to two-thirds of that at which the maximum was obtained in a static loading test by fracture of the wire. The cracks became invisible at zero stress up to and including the 8,000,000th repetition. A detailed report of these tests will be published later by the Commission. Thus these tests have conclusively proved, it is stated, the suitability of 0·276in wire for pretensioning, save only for qualifications about single untensioned wires (twisted wires in pairs are expected to be satisfactory, but it has not been conclusively proved), and suitable minimum spacing.

The tests specimens were made by Anglian Building Products, Ltd., who undertook the static tests at its works. Johnson and Nephew, Ltd., supplied the wire. The arrangements were all made under the direction of Mr. J. I. Campbell, M.I.C.E., chief civil engineer, British Railways, Eastern Region, in conjunction with the Railway Research Department, Derby.

UNITED STATES DESTROYER "TIMMERMAN"

ENGINE ROOM
FIRE ROOM
UPPER LEVEL.
ENGINE ROOM NO.2
FIRE ROOM NO.2
ENGINE ROOM NO.1
FIRE ROOM NO.1
LOWER LEVEL.
Boiler
Forced Draught Blower
Main Reduction Gear
Cruising Turbine
H.P. Turbine
L.P. Turbine
Main Condenser
Main Condenser Air Ejector
Turbo-generator
Turbo-generator Condenser
Distilling Plant
Deaerating Feed Water Heater
Aux. Gland Leak-off Cond. and Exhauster
Gland Leak-off Exhauster
Gauge Board
Main Switchboard
Fwd. Generator and Dist. Switchgear Group
Aft. Generator and Dist. Switchgear Group
Combustion Control Air Compressor
Combustion Cont. Air Accum. Tank
Mech. Cooling Chilled Water Circ. Pump
Mech. Cooling Unit
Air Cooled L.O. Cooler
Fuel Oil or Ballast
Fuel Oil Service Tank
Fresh Water Tank
Reserve Feed Water Tank
Cable Trunk
Shaft Trunk
Main Feed and Booster Pump
Boiler Circ. Pump
Feed Water Transfer Pump
F.O. Service Pumps
F.O. Service Pump (Port and Cruising)
F.O. Transfer Pump
Aux. Machinery S.W. Circ. Pump
Fresh Water Pump
Feed Water Transfer Pump
Combustion Control Panel
Main Condensate Pumps
Dist. Condensate Cooler
Dist. Circ. Water Pump
Dist. 1st Effect Drain Pump
F.W. Drain Tank
Main Cond. Pumps
Main Cond. Air Ejector
Main Condenser Circ. Pump
Turbo-generator Condensate Pumps
Turbo-generator Cond. Circ. Pump
L.O. Cooler
L.O. Discharge Strainer
Attached Main L.O. Pump
Main Reduction Gear
L.O. Purifier
L.O. Storage Tank
Motor Driven Main L.O. Pump
Planetary Reduction Gear Attached L.O. Pump
Planetary Reduction Gear Motor Driven L.O. Pump
Planetary Reduction Gear L.O. Cooler
Planetary Reduction Gear L.O. Filter
Dist. Feed Pump
Turbo-generator Cond. Circ. Pump
Turbo-generator Condensate Pump
Turbo-generator Condenser
Main Condenser
L.O. Settling Tank
Distilling Plant Panel
Distilled S.W. Heater Drain Pump
Dist. Brine Overboard Disch. Pump
Dist. Cond. Pump
Mech. Cooling Chilled Water Circ. Pump and Mech. Cooling Unit
Turbo-generator Air Ejector
Distilling Plant
CO2 Cylinders
F.O. Heaters
F.O. Discharge Strainers
F.O. Disch. Strainers
Port Use Blower
Combustion Cont. Air Compressor
H.P. Air Compressor
L.P. Air Compressor
L.P. Air Compressor After Cooler
L.P. Air Accumulator Tank
L.P. Air Compr. After Cooler
L.P. Air Accum. Tank
Combustion Cont. Air Accumulator Tank
Aux. Gland Leak-off Cond. and Exhauster
Gland Leak-off Exhauster
Cruising Reduction Gear
Cruising Turbine
Main Condenser Air Ejector
Distilled S.W. Heater Drain Pump
Dist. Cond. Pump
Turbo-generator
Turbo-generator Air Ejector
Distilling Plant
Distilling Plant Panel
CO2 Cylinders
Fwd. Generator and Dist. Switchgear Group
Gauge Board
L.P. Turbine
Cruising Turbine
H.P. Turbine
L.P. Air Compr.
L.P. Air Compressor After Cooler
L.P. Air Accum. Tank
Main Reduction Gear
L.O. Settling Tank
Gland Leak-off Exhauster
Aux. Gland Leak-off Cond. and Exhauster
Deaerating Feed Water Heater
Forced Draught Blower
Boiler
Port Use Blower
F.O. Heaters
F.O. Discharge Strainers
H.P. Air Compressor
CO2 Cylinders
Combustion Control Air Compressor
Combustion Cont. Air Accum. Tank
Mech. Cooling Chilled Water Circ. Pump
Mech. Cooling Unit
Air Cooled L.O. Cooler
Forced Draught Blower
Dist. Cond. Pump
Distilling Plant
Distilling Plant Panel
Turbo-generator

U.S.S. "Timmerman"—An Advanced Design Destroyer*

By COMMANDER D. G. PHILLIPS, U.S.N.†

THE U.S. Navy's Bureau of Ships has undertaken from time to time to procure and evaluate ships that have experimental machinery installations. The most recent and far-reaching of these undertakings was the design and development of the U.S.S. "Timmerman" ("AG 152"). The decision was made to build an advanced design destroyer whose main feature was a 100,000 s.h.p. machinery plant of equal or less weight and space than the 60,000 s.h.p. plant of the "DD 692" class—World War II—destroyer.

The "Timmerman" is presently undergoing evaluation trials which are as yet inconclusive. This paper constitutes a summary report based on the accomplishments to date, and is divided into four main sections: design objectives; machinery and hull features; progress and operational experience; trial programme.

Design Objectives

In order to attain a 100,000 s.h.p. machinery installation which could replace a 60,000 s.h.p. plant, the following items were considered:—reduction of design margins; elimination of the pyramiding of design margins; reduction in factors of safety; use of higher rotative speeds; use of higher voltage and frequency; use of better materials, taking into consideration critical materials which present a bottleneck during emergencies.

The circular of machinery design requirements for the "Timmerman" was prepared, based on the following general concepts:—

Except for shockproofness the technical portions of the general specifications were not to be applicable; machinery features were to be open to any new developments or designs leading to advancements in economy, space or weight, commensurate with reliability; guarantees were to be required only on workmanship and material, failure to meet performance requirements was not to penalise the shipbuilder or any sub-contractor; machinery life expectancy was specified.

The contract set forth the following general characteristics of the machinery plant:—

Full power	100,000 s.h.p.
Number of shafts	Two
Ship's maximum speed	Not less than 40 knots
Shaft revolutions per minute	About 350
Steam drum pressure	Not less than 750 lb per square inch gauge
Steam temperature at outlets of superheaters	Not less than 1,025 deg. Fah.
Steam pressure at superheater outlets	Not less than 700 lb per square inch gauge
Steam pressure at main turbine control valve	Not less than 650 lb per square inch gauge
Steam temperature at main turbine control valve	Not less than 1,000 deg. Fah.
Shaft horsepower astern	8,000
Ship's speed for best economy operating split plant	20 knots

Machinery and Hull Features

It was decided to use 875 lb per square inch, 1050 deg. Fah. steam for the starboard plant and 2000 lb per square inch, 1050 deg. Fah. steam for the port plant. It was anticipated that the optimum plant for naval use would employ steam condition somewhere between the two selected for the "Timmerman."

The design of the main steam piping system presented numerous problems incidental to factors such as steam pressure and temperature, thermal shock and weight. There was no information available on piping systems where temperatures of 1050 deg. Fah. had been employed and which were subjected to the number of complete heating and cooling cycles encountered in shipboard plants. It was anticipated that during the life of the vessel the main steam system would be subjected to a maximum of 4000 heating and cooling cycles. It was believed that stresses higher than the A.S.M.E. code allowed could be used to obtain thinner pipe walls. This would reduce thermal shock, increase flexibility and decrease the weight of the system. The piping materials installed in the ship as a result of tests were in conformance with the following specifications:—

	Ferritic (875 lb per sq in system)	Austenitic (2,000 lb per sq in system)
Carbon	0·14	0·08
Manganese	0·33–0·57	2·00
Phosphorus	0·025	0·03
Sulphur	0·025	0·03
Silicon	0·45	0·75
Nickel	—	9·00–13·00
Chromium	2·00–2·50	17·00–20·00
Molybdenum	0·90–1·10	—
Columbium	—	Stabilised (not more than 0·8)
Tensile strength	60,000	75,000
Yield point	25,000	30,000

An effort was made to make the piping system as simple as possible by employing the maximum number of welded joints. Austenitic steel was found to be suitable for welding, using either gas or arc welds. This was not true of ferritic steels. The most serious welding problem involved joining dissimilar metals, and tests indicated that satisfactory transition welds could not be made, thus necessitating the use of mechanical joints between the dissimilar materials.

The Rankine cycle was selected for both plants. Previous naval experience with reheat boilers indicated that there was little to be gained by going to a reheat cycle in this application. Studies were made in connection with bleeding steam from the main turbine crossover connection, but no serious consideration was given to utilising a regenerative cycle.

The machinery arrangement is shown in Fig. 1.

Starboard Propulsion Plant.—The starboard machinery installation utilises two single-furnace, single-uptake, natural-circulation boilers, capable of delivering 170,000 lb of steam per hour at 875 lb per square inch and 1050 deg. Fah. Fuel oil at 350 lb per square inch is supplied to the boiler through seven mechanical atomisers. Automatic combustion and automatic feed water controls are provided.

The superheater outlet temperature is a function of the boiler firing rate, with no separate superheat control provided. Between the firing rates for cruising and full power, the superheater outlet temperature varies between about 950 deg. and 1050 deg. Fah. The 875 lb per square inch boilers weigh approximately 100,000 lb each. Table I gives some of the significant data on these units:

Table I

	Boiler 1A	Boiler 1B
Operating pressure, pounds per square inch	875	875
Operating temperature, full power, deg. Fah.	1,050	1,050
Economiser inlet temperature, deg Fah.	240	250
Economiser outlet temperature, deg. Fah.	450	387
Total generating surface, square feet	3,332	3,370
Superheater surface, square feet	959	1,303
Economiser surface, square feet	1,994	2,690
Furnace volume	390	491
Rate of combustion, pounds of oil per hour:		
Full power	15,700	15,020
20 per cent overload	20,020	18,600

The main propulsion unit consists of cruising, high-pressure and low-pressure turbines in three casings with full power ratings of 50,000 s.h.p. ahead and 4000 s.h.p. astern. Steam inlet conditions are 815 lb per square inch, 1040 deg. Fah., with the low-pressure turbine exhausting to the condenser having a 25in Hg. vacuum. The cruising and high-pressure turbines are connected in tandem without a reduction gear. The series-parallel arrangement is used, with all steam being admitted to the cruising turbine up to about 25 knots. Above the cruising range, part of the steam is admitted to the cruising turbine and part to the high-pressure turbine. At maximum cruising condition, the cruising turbine delivers 3500 s.h.p. and at full power it delivers 9000 s.h.p. The engine combination has a turbine efficiency at full power about 3 per cent higher than World War II destroyer turbines. Turbines, valves and accessories weigh a total of approximately 46,000 lb, or 0·92 lb per shaft horsepower. The materials used in this turbine are as follows:—

Part	Principal alloying element(s)
Turbine casing and steam chest	2·5 chromium, 1 molybdenum
Turbine rotor	1 chromium, 1 molybdenum, 2 nickel, 0·25 vanadium
Turbine blades	13 chromium

Table II gives some of the more significant bearing data on these turbines at full power:

Table II

	Speed, ft per sec	Unit pressure, lb per sq in
Cruising journal, forward	131	115
Cruising journal, aft	152	160
H.P. journal, forward	152	277
H.P. journal, aft	174	267
L.P. journal, both	246	165
H.P. pinion journal, both	216	307
L.P. pinion journal, both	231	321
Gear journal, both	63	261

Some of the features of this turbine design are as follows:—Tip speed of the last stage blading in the low-pressure turbine is 1410ft per second; the cruising turbine utilises axial entry blade roots; the first stage of the high-pressure turbine is composed of a number of packs of welded blade assemblies, three blades to a pack; pivoted shoe bearings (four shoes per bearing) are utilised on both ends of the cruising and the high-pressure turbines.

In this turbine arrangement, the condenser is suspended from the low-pressure turbine girder. The high-pressure and low-pressure turbines are connected through a single reduction gear to the high-speed line shafting. The first reduction gear weighs a total of 9000 lb and has gear elements made of through-hardened alloy steel. Some of the principal data on this gear is given in the following table:—

	H.P. pinion	L.P. pinion
Shaft horsepower	19,000	31,000
Reduction ratio	5·49	4·18
Tooth pressure (total), pounds	20,400	33,400
Tooth pressure per inch face	2,270	3,720
Tooth pressure per inch face per inch diameter	191	238
K factor*	226	297

* $K = \frac{P}{D_p \times L} \times \frac{R+1}{R}$.

P = tangential tooth pressure, pounds.
D_p = pitch diameter of pinion, inches.
L = total width of active face, inches.
R = speed ratio.

The first reduction gear input speeds are approximately 10,000 r.p.m. on the high-pressure side and 7500 r.p.m. on the low-pressure side at full power. The output speed is 1800 r.p.m., thus permitting the use of 7¼in diameter shafting between the first and second reduction gear, a span of 72ft. This high-speed shafting is supported by seven trunnion roller bearings. A planetary gear is used for the second reduction gear that has an output speed of 350 r.p.m. This planetary gear is a single-reduction, double-helix unit weighing approximately 21,000 lb. Through-hardened alloy steel conforming to the following specifications is used in the sun and planet gears:

Carbon	0·38–0·43
Manganese	0·60–0·80
Phosphorus	0·040
Sulphur	0·040
Silicon	0·20–0·35
Nickel	1·65–2·00
Chromium	0·70–0·90
Molybdenum	0·20–0·30

Principal data on this gear is as follows:—

Shaft horsepower	50,000
Reduction ratio	5·1892
Speed of sun pinion, revolutions per minute	1,816
Speed of planet gear about its own axis, revolutions per minute	920
Speed of output shaft and planet carrier, revolutions per minute	350
Pitch diameter of sun pinion, inches	14·8
Pitch diameter of planet gear, inches	23·6
Pitch diameter of fixed ring gear, inches	62·0
Number of teeth in sun pinion	37
Number of teeth in planet gear	59
Number of teeth in ring gear	155
Face width of each helix, inches	5¼
Total combined face width, inches	12½
Diametrical pitch	2·5
Helix angle, degrees	30
K factor at sun pinion mesh, maximum	781
K factor at ring gear mesh	186

The starboard outboard shafting is supported by sealed anti-friction bearings, lubricated through the struts by gravity oil tanks, located in an after-ship's compartment.

Port Propulsion Plant.—This machinery combination consists of two single-furnace, single-uptake, controlled-circulation boilers, capable of delivering 160,000 lb of steam per hour at 2000 lb per square inch and 1050 deg. Fah. Fuel oil at 1000 lb per square inch is supplied to the boiler through four mechanical atomisers. Automatic combustion and automatic feed water controls are provided. As in the case of the

* Abstract of paper "U.S.S. 'Timmerman'—An Advanced Design Destroyer." Institute of Marine Engineers, March 29, 1955.

† Project Officer, U.S.S. "Timmerman," Bureau of Ships, Washington, D.C., U.S.A.

875 lb per square inch boilers, the superheater outlet temperature is a function of the boiler firing rate, with no separate superheat control provided. The two 2000 lb per square inch boilers each weigh approximately 130,000 lb. The following table gives some of the significant data :—

Operating pressure, pounds per square inch	2,000
Operating temperature, full power, deg. Fah.	1,050
Economiser inlet temperature, deg. Fah.	240
Economiser outlet temperature, deg. Fah.	380
Total generating surface, square feet	2,730
Superheater surface, square feet	1,200
Economiser surface, square feet	3,060
Steam air heater surface, square feet	1,120
Furnace volume, cubic feet	352
Rate of combustion, pounds of oil per hour :	
Full power	13,780
Overload 20 per cent	16,800

The circulating pump on each boiler is driven by a steam turbine using boiler pressure, and a motor drive with overriding clutch is provided for use during periods of lighting-off, low-load operation, and securing. The port main propulsion unit consists of cruising, high-pressure and low-pressure turbines in three casings with full-power ratings of 50,000 s.h.p. ahead and

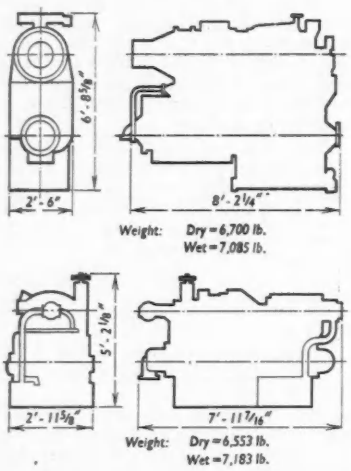


Fig. 2—600kW ships' service generators (upper), 815 lb per square inch, 1040 deg. Fah. unit, including condenser ; (lower) 1805 lb per square inch, 1045 deg. Fah. unit, including condenser

4000 s.h.p. astern. Steam inlet conditions are 1805 lb per square inch, 1040 deg. Fah., with the low-pressure turbine exhausting to the condenser having a 25in Hg. vacuum. Since the emphasis in the design of this turbine was on reduction in weight and space, the turbine efficiency is only about 1 per cent higher than designs in naval use at that time. The combined weight of the turbines, valves and accessories is approximately 59,000 lb or 1·18 lb per shaft horsepower. A single steam chest made of austenitic steel is mounted on the high-pressure turbine and furnishes steam to both the high-pressure and cruising turbine. Water spray for cooling astern blading is provided. The high-pressure and cruising turbine have double casing construction, utilising a solid outer casing with no horizontal flange. Blade material is as follows :—

Part	Principal alloying element(s)
Cruising turbine blading	12 chromium-cobalt-tungsten-vanadium
First-stage high-pressure turbine blading	12 chromium-cobalt-tungsten-vanadium
All other blading...	12 chromium, corrosion-resistant steel

The tip speed of the last stage low-pressure turbine blading is 1366ft per second. This blading is not shrouded, but is provided with a tie wire which passes through a hole in each blade. The wire is upset on each end to form a knob, but is not brazed to each blade.

In this turbine arrangement, the cruising turbine is by-passed at speeds above 25 knots, during which the exhaust is connected to the condenser. A small flow of steam is utilised to provide cooling for the cruising turbine when operating above 25 knots. The cruising turbine turns at about 14,000 r.p.m. when delivering rated horsepower and is connected to the high-pressure turbine through a single reduction gear without a declutching feature. The turbines are all supported by the condenser in this plant. The high-pressure and low-pressure turbines turn at 7500 and 6500 r.p.m. respectively at full power, and are connected to a locked-train, double-reduction gear with an output speed of 350 r.p.m. Through-hardened alloy steel gear elements, conforming to the same specifications as given for the planetary gear elements, are used in the double-reduction gear. The complete gear weighs approximately 35,000 lb. The following table gives some of the significant data regarding this unit :—

Gear element	Speed, r.p.m.	Horse-power	*K* factor
H.P. high-speed pinion	7,513	25,000	482
H.P. intermediate speed gears and pinions	2,210	12,500 each	369
L.P. high-speed pinion	6,502	25,000	431
L.P. intermediate speed gears and pinions	2,210	12,500 each	—
Low-speed gear	350	50,000	—

The inboard and the outboard shafting and bearing arrangement for the port plant is of conventional design.

Electrical Plant.—The electrical plant utilises a 1000V, 400-cycle, three-phase system, supplied by two 600kW synchronous turbo-generators. One unit, driven by a 1805 lb per square inch, 1040 deg. Fah. turbine, is a direct-coupled "package unit," turning at 24,000 r.p.m., with a static excitation system. The other unit, driven by an 815 lb per square inch, 1045 deg. Fah. turbine of the "package unit" design, direct coupled, turns at 12,000 r.p.m., and has a rotary exciter. There are two 250kW, 1000V, 400-cycle, three-phase emergency generators installed. The forward unit is driven by a gas turbine and the after unit is driven by a four-cylinder, two-cycle, radial diesel engine. The gas turbine installation has a ten-stage compressor and two-stage gas turbine rated at 410 b.h.p. (see Figs. 2, 3, 4).

All pumps and other auxiliary machinery, with the exception of feed pumps and main forced draught blowers, are driven by 950V, 400-cycle motors. These high-speed motors, utilising silicone insulation, are substantially smaller than conventional shipboard motors, thus realising appreciable savings in weight. It was found possible to utilise newly developed, small diameter power cable for the 1000V system, in spite of its having been designed for 440V, thus realising additional savings in weight (see Fig. 5).

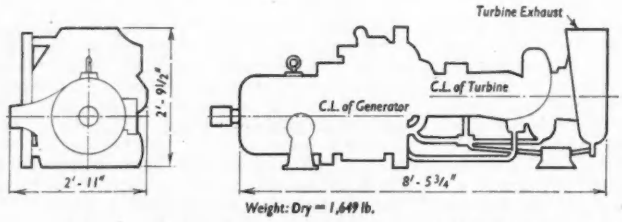


Fig. 3—250kW emergency generator set gas turbine driven unit

Miscellaneous Systems and Machinery.—The direct-contact, de-aerating feed water heaters, equipped with spray type vent condensers, are located in the fireroom rather than in the engine-rooms. Each of the two 2000 lb per square inch main feed and booster pumps are combined units. Each unit consists of a booster pump mounted on and driven by the feed pump shaft extended and is driven by a direct-coupled turbine, operating at rated boiler pressure and temperature. The 875 lb per square inch feed and booster pumps (both main and auxiliary) are also combination units, with a single turbine driving the feed pump element at turbine speed, and driving the booster element through a reduction gear.

TABLE III

Boiler served	Operating conditions	C.F.M.	T.S.P. inches of water	R.p.m.	No. of stages	
					Turbine	Blower
1A	Full power	26,350	69·7	5,400	6	3
	Boiler overload	40,000	165·0	7,750		
1B	Full power	28,600	90·3	5,725	6	3
	Boiler overload	41,250	184·0	8,000		
2A	Full power	26,900	68·5	5,650	5	3
	Boiler overload	36,700	125·0	7,750		
2B	Full power	26,900	68·5	5,650	5	3
	Boiler overload	36,700	125·0	7,750		

The main forced draught blowers are driven by turbines using steam at rated boiler pressure and temperature. These blowers are of the axial flow type and have the characteristics given in Table III.

Two of these units have air-cooled lubricating oil coolers and the remainder use salt water cooling.

The first reduction gear on the starboard shaft has an attached gear-driven lubricating oil pump. In addition, a motor-driven pump is provided for use during warming up, for speeds below about 10 knots.

TABLE IV

	"DD692" long hull	"Timmerman-AG" 152
Standard displacement, tons	2,425	2,425
Total shaft horsepower	60,000	100,000
Weight of machinery, tons*	938·7	835·8
Weight of machinery, pounds per shaft horsepower	35·0	18·8
Pounds per shaft horsepower in percentage of "DD692," pounds per shaft horsepower	100	54
Weight of electrical plant, tons† ...	137·6	61·5
Weight of electrical plant in percentage of "DD692" electrical plant	100	45

* Includes : wet weight of propulsion machinery and propulsion systems, propellers, shafting, independent plants and systems, smoke pipes, gratings, tools and equipment.

† Includes : generating equipment, switchboards, panels, transformers, motors, controllers, cable, tubes and wire ways. (Does not include degaussing cable and fittings.)

Machinery Weight Comparison : U.S.S. "Timmerman" and "DD-692" Class Destroyer.—Table IV is given to illustrate the advances made in the design and construction of the "Timmerman." A "692" class long hull destroyer is used as a reference, since the hull forms in each case are the same.

The ship is equipped with a new type steering gear which utilises a ball bearing nut and screw with hydraulic drive, in lieu of the conventional hydraulic ram system. This unit weighs approximately one-third as much as a standard destroyer steering gear. This large saving in weight is accomplished by replacing the hydraulic ram of about 11in diameter, used in a conventional system, with a ball bearing screw of about 4½in diameter. Instead of requiring two compartments the entire system is located in one compartment.

The twin rudders are mounted in roller bearings and fitted with seals. Provision was made for the installation of conventional sleeve bearings in the event the roller bearings failed. One of the rudders has medium steel plating, and the

other has plating of a special alloy steel containing nickel, thus enabling a comparative evaluation of the effects of water flow, erosion and corrosion.

Small, high-speed fans are utilised throughout the ship for ventilation and air conditioning. Higher air velocities have resulted in smaller duct work. Some of the smaller fans located in living spaces are encased in sound boxes and duct work sound insulation is employed in an effort to reduce noise levels. Two central compressor plants supply 17 tons of air conditioning to living and berthing spaces as well as to ship control spaces.

Progress and Operational Experience

At the beginning of the programme in 1946, it was anticipated that the completed ship could be delivered in three years. However, the "Timmerman" completed builder's trials in September, 1952, and was delivered to the Navy the same month. It was recognised that certain deficiencies existed at that time, but under the terms of the contract the shipbuilder was not accountable for failure of components to perform as anticipated, except in the case of defective material and workmanship, and there was no evidence of this.

The "Timmerman" was commissioned and fitted out at the Boston Naval Shipyard following delivery, and some of the difficulties encountered by the shipbuilder continued during the fitting out period. The following is representative of the more significant operational difficulties or material failures which occurred during the shipbuilding period, the fitting out period, or, in some cases, both.

Motors.—The 950V, 400-cycle motors are smaller, have less thermal capacity, and operate at higher speeds and temperatures than normally encountered. It is not surprising, therefore, that numerous failures, consisting of insulation breakdown, bearing failures, or both, have occurred. It is believed that a solution to these

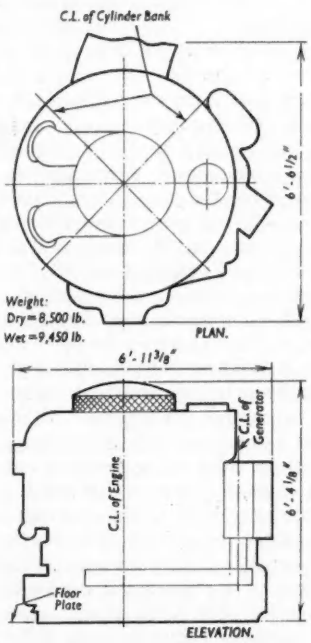


Fig. 4—Radial diesel driven generator

and other motor problems will be achieved as a result of carrying out the following programme now in progress :—

Using heat-stabilised, silicone-lubricated, anti-friction bearings, which are good for temperatures up to 150 deg. Cent.; paying particular attention to bearing housing and shaft fits, rotor balance, end bell fits, and the alignment of motor with the driven unit ; replacing, in some instances, relatively flimsy end bells of stamped construction with more rigid end bells of cast construction ; exercising closer control over silicone insulation application when motors are rewound.

Motor Controllers.—There has been a high incidence of motor controller casualties due to failure of relays, control transformers and contactors. Flash-over has occurred in some instances when the circuits have been interrupted. Modifications of controller arc chutes and contact points are being made in an effort to eliminate this condition. A further modification to the thermal overload relay, to ensure more positive overload protection, is being laboratory evaluated.

Turbo-Generators.—The electronic governor

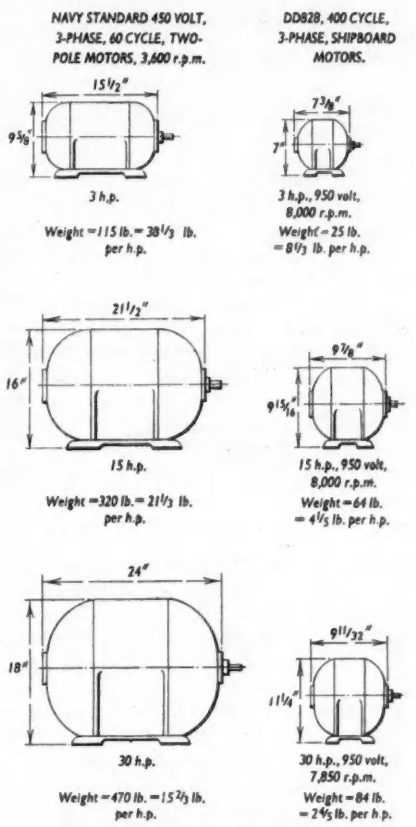

NAVY STANDARD 450 VOLT, 3-PHASE, 60 CYCLE, TWO-POLE MOTORS, 3,600 r.p.m.
DD828, 400 CYCLE, 3-PHASE, SHIPBOARD MOTORS.
15 1/2"
9 3/8"
3 h.p.
Weight = 115 lb. = 38 1/3 lb. per h.p.
7 3/8"
7"
3 h.p., 950 volt, 8,000 r.p.m.
Weight = 25 lb. = 8 1/3 lb. per h.p.
21 1/2"
16"
15 h.p.
Weight = 320 lb. = 21 1/3 lb. per h.p.
9 7/8"
9 15/16"
15 h.p., 950 volt, 8,000 r.p.m.
Weight = 64 lb. = 4 1/5 lb. per h.p.
24"
18"
30 h.p.
Weight = 470 lb. = 15 2/3 lb. per h.p.
9 11/32"
11 1/4"
30 h.p., 950 volt, 7,850 r.p.m.
Weight = 84 lb. = 2 4/5 lb. per h.p.

Fig. 5—Weights and dimensions of 60-cycle motors compared with 400-cycle motors

system on number 1 turbo-generator has not given the desired speed and frequency control, and several failures of tubes, relays and transformers in this circuit have occurred. The possibility of replacing this system with a mechanical governor is being considered. Experience with the high-speed rotary exciter has led to the decision to replace it with a static excitation system. Extensive modifications to the number 2 turbo-generator were required. The capacity of the machine was found to be less than anticipated, due to internal shorting in the field coils and arcing in the slip rings. Modifications to this unit included rewinding the rotor and increasing the field turns, installing new bearings and oil seals, resurfacing journals, and installing new sliprings and brush holder assembly which accommodated additional brushes, thereby reducing current density. Additional rectifiers were provided in the excitation system, and a cooling system was provided for the separately mounted rectifiers.

Emergency Generators.—The gas turbine presently installed has these features :—

Electric starting, to replace air starting, making the unit independent of the compressed air system.

Increased air ducting area, supplied from outside air rather than compartment air.

Removal of exhaust muffler and increasing exhaust collector exit area by approximately 55 square inches.

Increased horsepower to allow unit sufficient power to operate at rated 250kW generator output.

Installation of a fuel line accumulator and an acceleration limiter.

The diesel emergency generator was modified to provide for an oil-lubricated bearing in the generator end, which replaced a grease-lubricated bearing. This was done as a result of several bearing failures after relatively short periods of operation and it was felt that a grease-lubricated bearing for this application was marginal.

Valves.—Due to the high exhaust temperature, exhaust valves fitted with internal threads were soon rendered inoperative and valves with an externally threaded yoke were used to replace them. Cracks were found in the stellite seats and discs of several valves in high-temperature steam lines, and a different stellite alloy, having better elongation properties, is being evaluated.

Number 1 Low-Pressure Turbine.—Leakage in the after bearing oil seals has occurred on several occasions. Steam deflectors were found necessary to prevent astern steam impingement on ahead blading in the low-pressure turbine during astern operation. Furthermore, a partial loss of vacuum has occurred during astern operation and vacuum recovery after astern operation has been extremely slow. Rubbing of the radial seal strips was found to have occurred, which necessitated reboring the after bearing housing in order to re-establish the correct rotor position. To date, the maximum speed attained has been 34 knots, which corresponds to about 60 per cent of the full power rating of the ship. The deficiencies which have prevented the use of higher powers are gradually being corrected and it is expected that in the near future full power trials will be possible. It is anticipated that speeds approaching 40 knots will be reached during these trials.

Trial Programme

In order to evaluate the many unique features included in the design of the "Timmerman" an extensive trial agenda has been prepared. The trial programme is broken down into three major phases, the first of which is complete. There was a total of about twenty tests in this group and they consisted of evaluating individual pumps, valves, auxiliaries and minor systems.

The second phase trials and tests includes :

Automatic steering control tests ; vibration trials ; noise trials ; observation and photography of cavitation ; pressure measurements ; boundary layer survey ; standardisation trials and transient thrust and torque determination ; tactical trials ; astern turbine deceleration performance trials.

The final phase of the trial agenda consists of main turbine water rate, fuel economy, and heat balance trials. During these trials, performance data will also be obtained on individual components, such as boilers, main condensers and air ejectors, lubricating oil coolers, fuel oil heaters, and other units making up the main propulsion plant. The results will indicate the fuel economies which can be realised from going to higher steam pressures and temperatures, and will form a basis for the selection of steam conditions and components to be employed in future designs of naval propulsion plants.

British Standards Institution

All British Standards Specifications can be obtained from the Sales Department of the Institution at 2 Park Street, London, W.1

STEEL ROLLER CONVEYORS

No. 2567 : 1955. Price 2s. 6d.—This new standard specifies important dimensions of the principal components of fixed and portable roller conveyors, within the range of maximum loading from 10 lb to 320 lb per roller. It does not apply to power-driven roller conveyors.

BROAD-FLANGE BEAMS, HEAVY-FLANGE T-BARS AND LONG-LEGGED T-BARS

No. 2566 : 1955. Price 2s. 6d.—This standard extends the range of standard sections covered by B.S. 4, "Channels and Beams" ; B.S. 4A, "Equal Angles, Unequal Angles and T-Bars" ; and B.S. 6, "Bulb Angles and Bulb Plates."

The new sections have been standardised as up to now the range of standard sections did not cover fully the requirements for welded construction. Consideration was given to a wide range of special sections, which from time to time had been put forward as incorporating factors which would facilitate their being welded. The most useful and economical sections are stated to be covered in this standard.

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MOTOR ROAD CONSTRUCTION

The technical and economic problems of road construction were debated on two occasions last week—at meetings of the Pavings Development Group of the Cement and Concrete Association, and of the Institution of Highway Engineers. The economic importance of achieving a good highway system was emphasised, at the Institution of Highway Engineers' debate, by Mr. C. T. Brunner, who pointed out how the road system had been starved of capital, and how even with the Government's recent proposals, the share of capital to be allocated to it falls short of that envisaged for other comparable industries. Mr. Brunner advocated an expenditure of £75,000,000 a year, for ten years, which, he said, would give a return of at least £200 million a year in the form of savings in operating costs and prevention of accidents. He also recommended the formation of a National Highway Authority, which would be responsible for the road programme, being a body somewhat analogous to national bodies such as the Atomic Energy Authority or the British Transport Commission. The next speaker at the meeting, Lieut.-Colonel A. C. Newman, remarked that since the Government had announced its road programme, there had been a certain amount of contention that the programme might interfere with the load of work carried out by the building and civil engineering industry at the present time. He pointed out that the industry had a holding of plant valued at over £100 million, and gave detailed figures of the quantities of plant of various kinds owned by contractors, and of estimates for the supply of the various classes of materials necessary for road work, which clearly indicated that there were resources to spare. Lieut.-Colonel Newman also emphasised that fewer large aerodrome contracts were coming out; the industry considered, therefore, that it was in a favourable position to participate in a road programme. The labour from the aerodrome works could not easily be merged into a building programme, and if there were a gap between that work and the road work, skilled men were likely to be lost to another industry or another style of work. The third principal speaker at the Institution's debate, Sir Owen Williams, said that for every car produced in the factories, £500 needed to be spent on the roads on which it was to run. He drew attention to a number of factors making for more economical design.

At the Pavings Development Group's meeting, the construction of concrete roads and bridges was discussed. One of the papers on bridges is reproduced on page 500 of this issue; other papers at the morning conference described the less spectacular, but equally important, work on the smaller bridges, outlining the achievements of various systems of construction. The meeting continued in the afternoon with a discussion of the paper "The Application of Lessons Learnt in Airfield Construction to the Construction of Concrete Roads," by J. M. Laing, J. M. Fisher and E. U. Broadbent, and also of "Concrete Road Construction in the Netherlands, with Special Reference to the New Motor Roads," by Ir. J. G. N. Ringeling. A different emphasis was placed on the problem of plant at this meeting, arising from the review of the plant and likely constructional methods for roads given in the paper by Messrs. Laing, Fisher and Broadbent. A programme of extension and strengthening of airfields has proceeded steadily during the past eight years or so, and a great deal of experience has been accumulated. Airfield contracts have been gained against keen competition, which has been a factor in encouraging better constructional techniques, in reducing the cost and in giving results of consistently high quality. Mr. Laing pointed out that, apart from excavation, airfield paving had become the most highly mechanised operation in civil engineering. He instanced a case where an airfield project had been built with 600 men (150 of them staff) where 2000 to 2500 men would have been needed for the same work as it was carried out during the war. In such a case, the economy in manpower needed an expenditure of £300,000 or £400,000 on plant. Road works would be on a smaller scale than airfield construction of this kind and the view was expressed that the plant needed would be rather different. There seemed to be, particularly, a need for concrete batching and mixing plant adapted for road work. The relative merits of the bridge mixer and the paver, for building a 24ft carriageway, were discussed, and neither of them seemed the ideal answer in the opinions of the various speakers. A batching and mixing plant, capable of producing 20 to 25 cubic yards of concrete an hour was described as relatively easy to move, but if it had to be moved every 1½ miles or so, perhaps 3s. per cubic yard would be added to the cost of the concrete. Mr. Laing's comments on the future road programme, although professedly from the contractor's point of view, are worth noting. He considered that specifications (a more or less standard form of specification is an obvious advantage) should call for a high standard which should be rigidly adhered to throughout the work. He also thought that the quality of the work would be safeguarded by tendering by invitation to selected firms.

It is clear from the facts given by these various authorities that the contracting industry will have no difficulty in coping with the Government's road programme, and could, in fact, meet the requirements of a larger programme. Circumstances may, indeed, force the pace, for 1,500,000 more road vehicles are forecast by 1958; all these facts confirm that Mr. Brunner's proposals are not unduly extravagant. As far as civil engineering plant is concerned, there are adequate resources available, but there seems to be a challenge to plant manufacturers to produce new designs, which would be ideally suited to carrying out road works with the maximum economy. Although the security aspect of the airfield programme prevents us from giving a concise assessment of its scope, it is evident that rapid technical progress has been made, and the present state of the art reflects considerable credit on the civil engineers concerned. The establishment of a regular and continuous programme of road work would undoubtedly have a similar, highly beneficial influence on the technical progress of road building. Once such a programme is established, many of the problems now discussed will fall into a clearer perspective as experience is accumulated.

DETERRENCE WITH DEFENCE

The Minister of Defence has hitherto kept Parliament informed of the size and strength of the Soviet Armed Forces and it is to be hoped that he will continue to do so. Russia's existing forces were built up, or planned, before the Kremlin could have had full knowledge of the vast destruction to be

expected from the hydrogen bomb and they are in any event far in excess of her requirements for any form of "cold" war. If they are now still further strengthened, or even maintained at their present strength, it might well be assumed that the Soviet Government either continues to hope for a ban on nuclear missiles or is not unduly dismayed at the prospect of a nuclear war and will persist in such long-term plans for aggression as it may have in mind. What, indeed, would be Russia's object in maintaining 175 divisions and a navy of thirty powerful cruisers and 500 submarines if she believed her cities and ports and industrial areas likely to be destroyed within a few days and her people left to carry on "a struggle for survival of the grimmest kind"? But whatever the effect on the Kremlin of the Defence White Paper, Britain has no alternative but to manufacture the hydrogen bomb and to build up her own bomber force, thus adding to the deterrent already provided by the immense strength of the United States Strategic Air Force. To leave the deterrent entirely in American hands would deprive this country of any effective voice in determining when to use it and what targets to select or even in deciding N.A.T.O.'s overall defence policy. It seems, in fact, clear from the recent defence debates that many Members of Parliament, representing a substantial body of opinion, had these points in mind when approving the White Paper. They believe that with Britain exercising a restraining influence on the use of nuclear weapons, the Soviet Government, knowing the consequences, would not deliberately start all-out aggression on the Continent of Europe.

Though deterrence is now intended to be our most effective defence, the defence measures required if the deterrent fails to deter could have been discussed at greater length, without detriment to security, both in the White Paper and in the subsequent debates in Parliament. Britain is an essential base for reinforcements, supplies and offensive operations and must have the best possible defence against bombing attacks if she is to survive. Ground-to-air guided missiles are not yet in production in this country, but they are being produced in quantity in the United States, where batteries of four guided missile launchers are being erected for the defence of every one of her principal cities. It may well be that consideration has been given to the purchase of a supply of these missiles from America to meet our immediate needs, but that finance rules out this costly form of ground defence in view of the decision to build up a deterrent bomber force of more than token size. Or it may be that it has been concluded that our small island could be defended more effectively by large numbers of interceptor fighters with air-to-air guided missiles. But why, in that event, do we continue to arm our fighters with 30mm Aden cannon when they will have no more than ten minutes' warning to intercept bombers at heights of 10 to 12 miles, with both bombers and fighters flying at supersonic or near supersonic speeds? Reliable air-to-air missiles have already been issued to U.S. Air Force and Navy fighters. The British people have a right to have authoritative information on these points if they are to be encouraged to keep the hydrogen bomb in proper perspective and to realise that the Navy's task of safeguarding our imports of food and raw material has lost none of its traditional importance.

Some aspects of our naval defence policy also call for explanation. Despite the age of many of our cruisers, no more cruisers of the conventional type are to be built in view of the guided missile ships which are in sight. Guided missile ships are not, however, to be laid down, pending the results of the trials of the experimental ship due to be commissioned next year. They are thus unlikely to be in service for another four or five years. Moreover, they will still apparently have guns as their main armament, pending production of a reliable worth-while ship-to-ship guided missile. Their guided missile armament is purely for anti-aircraft defence. Would it not be practicable to lay down these ships forthwith, and provide them with the United States ship-to-air "Terrier" guided missiles, rather than wait for the trials of our own anti-aircraft missiles? There are the Soviet "Sverdlov" class cruisers with 7·1in guns to be dealt with in the meantime, and if we are not to rely on the United States cruisers—which may be fully engaged in the Pacific—it is surely taking unnecessary risks to regard the carrier and her aircraft as the answer. No new carriers are provided for in the Navy Estimates and Britain will thus have only seven of these ships capable of operating modern jet aircraft. They cannot be defending trade in the Atlantic and Indian Oceans if they are also, in the words of the White Paper, "to contribute to the Allied striking Fleet . . . which will add powerfully to our ability to hit the enemy either independently or in support of Allied land forces and land-based forces." It appears also, from the recent debates in Parliament, that the function of British carriers in this connection is not clearly understood. There is no intention of following the Americans in building 60,000-ton carriers to launch large, heavy, medium-range bombers against targets 1000 miles inland. None of our carriers is large enough to operate aircraft of this kind. They will "hit the enemy" by bombing his harbours and military installations on or near the coast with "Wyverns"—or the strike aircraft foreshadowed to replace them. Strategical bombing, in the British view, is the function of the Royal Air Force. None the less, the offensive role now given to the Navy will greatly encourage officers and men to have faith in the future of the fine Service to which they belong. Despite the submarine menace and nuclear weapons, Nelson's doctrine still stands—the surest defence of England is to place the Navy alongside the ports of the enemy.

Obituary

LEWIS HOLME LEWIS

WE record with regret the death of Mr. L. Holme Lewis, who was for many years the chief engineer and manager of Manchester Corporation Waterworks, and whose career is particularly associated with the Haweswater water supply scheme. Mr. Holme Lewis died on April 3rd; he was in his eighty-ninth year.

Lewis Holme Lewis was born in Carmarthenshire in 1866. He was educated at Pencader Grammar School, and at Chester School of Science and Liverpool University. Then, he was articled for five years to the Hydraulic Engineering Company of Chester, after which he served as manager of the company's Liverpool branch, and from 1891 to 1895, of its London branch. In 1895 he joined the Manchester Corporation as chief engineer and manager in charge of its hydraulic power supply. He was appointed chief engineer and manager of Manchester Corporation Waterworks ten years later, in 1905, and he continued to serve in that capacity until his retirement in 1931, after which he continued to be responsible for the construction of the first instalment of the Haweswater scheme, which was designed and constructed under his direction.

In 1929 construction of the Haweswater scheme was started; the works were to include the reservoir, and an aqueduct with one line of pipes to the Heaton Park reservoir in Manchester. However, the scheme was suspended in the financial crisis of 1931. It was then decided to restrict it by building only about 9 miles of aqueduct, to connect with the existing Thirlmere aqueduct; a new Act of Parliament was thus needed, and work was again started in 1934. The modified scheme was completed in 1941. The Haweswater aqueduct itself was started after the war, and the first pipeline is only now approaching completion. The original scheme was of note because of the design of the Haweswater dam, which was the first buttress structure to be built in this country. The dam has a height of 120ft and consists of forty-four buttresses; the reservoir has a capacity of 18,660 m.g.

Apart from his managing the affairs of the Manchester Waterworks, Mr. Holme Lewis directed the construction of works such as the 550 m.g. service reservoir at Heaton Park, and the completion of the Thirlmere aqueduct. Of this work, the *Manchester Guardian* wrote, at the time of his retirement in 1931: "It was originally intended that the Thirlmere aqueduct should consist of five pipelines, but when the construction of the fourth line was under consideration, Mr. Holme Lewis proved, after much careful research, that it would be more economical to lay a large pipe, 54in in diameter, which would be capable of conveying to Manchester the remainder of the total daily yield from Thirlmere. Nor was this all. Instead of continuing the pipe to Manchester, in accordance with the original intention, he merely took it to Lostock, where he erected a booster station, of his own design, by means of which the water delivered from the fourth pipe was conveyed under pressure to Manchester through the three existing pipes. In this way he effected a saving in capital expenditure amounting to about £500,000."

In 1926, Mr. Holme Lewis was elected president of the Institution of Water Engineers. It is worth recalling that in his presidential address he advocated the need for research in water engineering and suggested contributions by water authorities towards the cost of maintaining a branch of the Royal Scientific and Industrial Research Department, as it then was, devoted to water supply problems. He also emphasised the responsibility of the water engineer in avoiding expenditure on new schemes in advance of actual requirements. He was a member of the Institutions of Civil and Mechanical Engineers, and a member of the executive committee of the British Waterworks Association. He also served on governmental committees on water supplies and river pollution.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

HYDRODYNAMIC LUBRICATION OF ROLLER BEARINGS

SIR,—We were interested to read Mr. Lewicki's reply (THE ENGINEER, March 11, 1955) to our criticism of his paper. The argument, in which a body is held to be in equilibrium under the action of two mutually perpendicular forces (N and T in Fig. 5) or of an unbalanced moment [$R(T_P+T_C)$ about the axis in Fig. 6], is certainly ingenious, but is unacceptable in conventional mechanics.

Mr. Lewicki's lengthy attempt to reconcile elastic and hydrodynamic forces and to prove $\delta=0$ is unconvincing and merely shows the incompatibility of his own simplifying assumptions. The re-assertion that in his analysis normal pressures outside the flat are negligible is in contradiction of the evidence of his own equation (13). The inlet pressure to the flat (equation (13)) could itself have been obtained in a less unsatisfactory manner by a suitable modification of Martin's analysis (*Engineering*, 1916, 102, 119). Equation (31) would have been still " more accurate " if it had obeyed Newton's Third Law of Motion.

Mr. Lewicki's " correction " of equation (11) in our letter is a mere rewriting in more general terms ; both equations (11) and (12) are correct as printed. We thank Mr. Lewicki for pointing out the misprint in the figures (" α " should replace " a ").

Reference to the work of Professor H. Blok (*Journal Inst. Pet.*, 1952, 38, 673 and elsewhere) is necessary to place Mr. Lewicki's theory in its proper context. It has been shown that the exact solution of the balance between hydrodynamic and elastic forces is difficult, but that it can be done by numerical methods (see also H. Poritsky, *Fundamentals of Friction and Lubrication in Engineering*, First A.S.L.E. National Symposium, 1952, page 98, and J. Dörr, *Ing-Archiv.*, 1954, 22 (3), 171–193). The merit of Mr. Lewicki's assumption of a flat lies in the possibility of thereby obtaining an approximate analytical solution for a particular range of conditions. This may not be the best assumption that might have been made, but it would seem to be worthy of examination, provided that it is applied consistently and with correct mathematics—hence our criticism.

A. A. MILNE
J. A. COLE

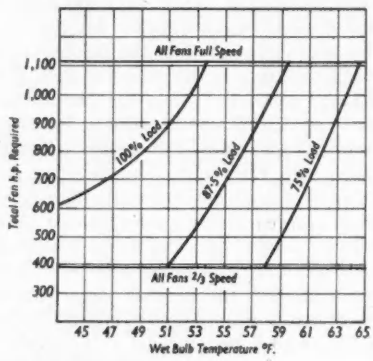
March 31st.

ECONOMIC SELECTION OF COOLING TOWERS

SIR,—On February 4, 1955, you published an article by Messrs. Kennedy and Margen entitled " Economic Selection of Cooling Towers for Generating Stations." Mr. J. Leitersdorf, a member of our technical staff, was present when this paper was read before the Institution of Electrical Engineers on January 5th, and has asked that the following points be considered in connection with this paper.

In Section 5, entitled " Economic Operation," reference is made to shutting down fans under reduced load conditions. This is definitely the wrong procedure. The correct operation should make use of the enormous power saving which results from reducing the fan speed whereby the air flow varies only directly as the fan speed, while the power consumption drops as a cube function. This factor is important when considering the exhaust heat load limitations which apply for any given steam turbine as described in the paper. Since for any particular case there will be no advantage in an increased vacuum when the wet bulb temperature falls below the design wet bulb temperature, advantage should be taken of the considerably reduced power consumption obtainable by reducing the air rate but at the same time maintaining the design water temperature. In small cooling tower installations, the fan speed may be varied most readily by using two-speed motors. In larger installations, single-speed motors may be used in conjunction with an elementary form of frequency changer which will result in a simple, cheap and robust installation.

It should be emphasised that two-speed operation of the fans will produce all the necessary



Design vacuum : 28·7in Hg.
Inlet water temperature : 83·8 deg. Fah.
Outlet water temperature : 65·8 deg. Fah.
Design W.B.T. : 53·6 deg. Fah.
Water quantity : 3,280,000 i.g.p.h.

Horsepower requirements of fans of induced draught cooling tower for condenser of 110MW turbo-alternator

fluctuation one requires and to illustrate this point the attached curves have been drawn. They are based on a scheme for a Continental power station utilising automatic control to maintain constant vacuum by changing fans from full to part-speed operation, according to requirements. It will be noticed that full-speed and two-thirds speed fan operation has been used. For the above reasons it is also completely misleading and incorrect to base economic calculations on seasonal block load allocation diagrams illustrated at the top of page 2 of the paper. Analysis in this manner must mean a much larger period of time calculated as full-load operation than occurs in practice. With horsepower varying as the cube of the fan speed the errors will be large ; hence, accurate load diagrams must be used in such an analysis which, unfortunately, will make the calculations tedious, but very necessary, to obtain accurate results. If these necessary complete calculations are made, it will be found that the economic justification which mechanical draught towers have achieved in all other parts of the world will be attained also in this country.

W. C. PATERSON,
Publicity and Advertising Section,
Projects Initiation.
Head, Wrightson Processes, Ltd.,
Teesdale House, Baltic Street, London, E.C.1,
March 15th.

Short Notices

Fifty Years on Tracks. Caterpillar Tractor Company, Peoria, Ill., U.S.A. Price 1.25 dollars. —Last year the Caterpillar Tractor Company celebrated the fiftieth anniversary of the introduction of the crawler tractor, and it has now published this interesting book which traces the background and the development of this form of tractor and its many applications in agricultural, industrial, military and other equipment. The Caterpillar Tractor Company was formed by the merging of the C. L. Best Tractor Company and the Holt Manufacturing Company in 1925, but the crawler track itself was first introduced by the latter company in 1904, in an attempt to overcome the problem of using large heavy steam tractors on soft ground. The first production model of a crawler steam tractor was made and sold by the company in 1906. In the same year an experimental crawler tractor driven by a petrol engine was tested and this design was first put into production only two years later. From then on the use of the internal combustion engine propelled crawler tractor steadily increased as it replaced the horse and the mule for drawing agricultural, constructional and military equipment of all kinds. Each significant development in design and new application of the crawler tractor is described and illustrated in the book, which concludes with notes on the manufacture of a " D8 " machine and the general activities of the company.

Optical Glassworking. By F. Twyman, F.R.S. London : Hilger and Watts, Ltd., 98, St. Pancras Way, N.W.1.—This is an abridged edition of the author's book on " Prism and Lens Making," and it has been written as a text book to meet the needs of those engaged in or studying optical glass making. It opens with a concise historical review of the subject and goes on to deal with the methods of making by hand of a single prism or lens. After a subsequent section on the tools and materials in general use in the industry descriptions are given of the methods and equipment for producing lenses in quantity, spectacle lenses, microscopic lenses, prisms in numbers and non-spherical surfaces. Having dealt with the manufacturing side, sections are then devoted to the all-important subjects of testing optical work and glass, and surface treatments. The book concludes with an interesting chapter on the working of large object glasses and mirrors and the problems involved. Mr. Twyman has long been recognised as a leading authority on the processes involved in high-class optical work, and this abridged version of his original book, which deals mainly with the practical aspect of the subject, will be welcomed both by students and those engaged in the practical side of optical glass working.

Radar Pocket Book. By R. S. H. Boulding, B.Sc., M.I.E.E., A.M.I.Mech.E., F.Inst.P. London : George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 15s.—This book of 174 pages gives the basic electrical principles of radar, amplified by information about the component parts of a radar installation. Typical circuit diagrams are given, with a brief explanation of their operation. The author has achieved a considerable feat of compression in this book and, although it does not purport to be a comprehensive textbook on the subject, it should appeal to engineers and operators who may be interested in the construction, installation and use of radar equipment.

Books Received

The Testing of High Speed Internal Combustion Engines. Fourth edition. By A. W. Judge. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

Blueprint Reading for the Machine Trades. By R. H. Fortman and J. McKinney. London : The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.8. Price 18s.

Gas Turbine Principles and Practice. Consulting editor, Sir Harold Roxbee Cox. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 90s.

Irrigation and Hydraulic Design. Vol. I : General Principles of Hydraulic Design. By Serge Leliavsky. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 126s.

A History of Mechanical Inventions. Revised edition. By A. P. Usher. Harvard University Press. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 72s.

Studio Engineering for Sound Broadcasting. General Editor J. W. Godfrey. Published for *Wireless World* by Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 25s.

An Explaining and Pronouncing Dictionary of Scientific and Technical Words. By W. E. Flood and M. West. London : Longmans Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 12s. 6d.

The Role of Petroleum in Modern Transport. Report of the Institute of Petroleum Summer Meeting. Edited by George Sell. London : The Institute of Petroleum, 26, Portland Place, W.1. Price 30s.

Surveying. Solutions to B.Sc. (Eng.) Exam. Questions of London University (External). By D. H. McPherson and P. N. Ray. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 18s.

Applied Mechanics

No. I

At a meeting of the Institution of Mechanical Engineers, which began after lunch last Friday and continued into the evening, a number of papers were read and discussed. The meeting was organised by the Applied Mechanics Group and we here print summaries of the papers and abstracts from the discussions.

THE first paper presented at a meeting of the Institution of Mechanical Engineers last Friday, was :

BENDING STRESSES IN SPUR GEAR TEETH : PROPOSED NEW DESIGN FACTORS BASED ON A PHOTO-ELASTIC INVESTIGATION.

By M. A. JACOBSON*

The paper embraces three related subjects : photo-elastic measurement of stresses in spur gear teeth ; interpretation of stresses so found to give revised strength factors for B.S. specification on the design of spur gears ; and a tentative attempt to correlate the stresses found with fatigue-test results which have been reported by various investigators.

The object of this paper is to propose maximum safe bending loads which involute spur gears can be allowed to carry. The gears investigated are confined to those which can be generated by standard cutters conforming to the 20 deg. pressure-angle, B.S. basic rack, without either causing under-cutting near the root or undue pointing of the teeth. The values proposed are based on a photo-elastic investigation carried out by the author under the guidance of Professor W. A. Tuplin, at the Post Graduate School of Applied Mechanics, Sheffield University.

Strength factors for spur gears are given in the form of charts. These factors embrace the whole possible range of spur-gear combinations, both with and without addendum corrections.

To enable a rational assessment of strength to be made, a list of service factors, as well as a graph correlating bending-fatigue data for three classes of surface finish (ground and polished, shaped, hobbed) are given.

DISCUSSION

Dr. H. E. Merritt : As you know, the literature on this subject is truly enormous, nevertheless practically nothing is known about the things which really matter, and that refers particularly to load carrying capacity ! I hope that Mr. Jacobson will not be disappointed if some of my comments appear to be a little critical. I should like to try and add a little background to the subject in the hope that it may be of interest to Mr. Jacobson to know how one who has been trying to design gears that work for many years visualises this as a contribution to the subject.

So far as the actual practice of gear design is concerned, I note that the author is anxious to improve the technique or practice of gear design, and I am sorry if I can do no more than to say how difficult that is. First of all, if we take it in categories, there are a number of people who use formulæ for gear design. The first category we can regard as the engineer who is responsible for purchasing gear units for a large installation. He is not a gear specialist. He wants to be assured that those gears are made to a recognised code of practice, and he may specify that the gear shall be in accordance with British Standards Specification No. 436. He is not concerned with how that specification is built up. He is completely ignorant of the many errors and rash assumptions which that specification contains. The second category contains industrial firms who are designing gear units of a particular type and who need some quick and consistent method of estimating gear sizes so that when they fit something this week, it will be the same size as the one they fitted last year. When one considers what is hoped to be a universal formula for gear design, one has to remember that it has to cover a very wide range of operating conditions. The variables which come into the actual loading of the gears are so many and so uncertain that the margin of safety in any such universal formula is not only large in itself, but is also largely variable and its variability is unknown. For example, there are many gears which have been tested under laboratory conditions at eight times the loading represented by the British Standards rules, and gears have been in quite good condition after 100 million revolutions. On the other hand, there are industrial gears which have been rated within the limits set down by British Standards Specification No. 436 and which have given a great deal of trouble. So we have an unknown variation of something between eight and one. Until we can do something about that variation, the paring down of small differences in the individual factors is of less importance.

In so far as the bending strength of the teeth is concerned, the strength factor is given in the British Standards Specification, and its derivation contains a number of rash assumptions and errors of calculation, and is not therefore by any means ideal. All that one can say at the moment is that the errors in those strength factors are much less than the variables elsewhere. That does not mean that one should disregard the errors in those factors, of course. It is not really as bad as it seems. Nevertheless if, as he does in his paper, Mr. Jacobson suggests that by comparing his experimental results with the results obtained by other physical tests, he would recommend an increase in bending stress above that in British Standards Specification No. 436, he should be a little cautious. I do not think that anyone would dare do it. I once made a very rash move myself in modifying a gear rating on the lines of pure reason, but unfortunately the small gears were perfectly all right and the large gears broke right and left!

There is a third category of user of gear design methods. The people in that category are those who are concerned only with a limited range of designs of gearing, where they have the factors under control and where it is most important that maximum economy in design should be adopted. People in that position do need all the information that they can obtain on the strength of gear teeth as well as of their load-carrying capacity. It is people in that category who stand to gain most of the work of the kind that the author has been doing. In order, therefore, that Mr. Jacobson's work can really be made as effective as possible, I would suggest that he re-examines whether he could not add to or enlarge upon the way in which he has presented his results so that they are more suitable for application to new designs, and also so that they are more in line with current practice of people engaged in gear design. He has presented his results in the way advocated by Professor Tuplin, which is a peculiar method of describing or defining the amount of modification. I think that a large number of people would have understood Mr. Jacobson's paper more readily if he had presented his results in the accepted way. If he could so arrange the presentation that interpolation were not necessary, it would, I feel, be a further advantage.

In so far as the author's charts giving complete strength factors are concerned, the figures which appear on page 8 of the paper give strength factors against the numbers of teeth and the difficulty of the ordinary gear designer in using that information is that in these charts there is inherent a very radical assumption about the point of the profile on which the tooth load is actually applied. Not everyone would agree with that and I would hope that the author might find it possible to devise some other method of presenting his experimental data, possibly along the lines of Dolan and Broghammer, in which the stress calculated by the erroneous method can be converted into real values by applying the stress concentration factor. It is easy to draw out the tooth profile and determine the stress, but if one could easily apply a factor which would give the correct result case by case, then we should have a much better opportunity of analysing our current practice and improving upon that practice.

Mr. J. L. H. Bishop : In view of the photo-elastic tests, it would appear on the face of it that the bending strength factors of the B.S. 436 based on evaluation of cantilever strength, stand in serious need of revision. Since, however, Mr. Jacobson covered such a wide range of possible centre distances or, to use his own expression, " S " values, the deviations in strength factor for a narrower band of gear applications may not be so serious. This could only be verified by a series of stress calculations. It was hoped to have these figures available for the discussion, but unfortunately this has not been possible. Whatever new method is adopted in the revision of the B.S. handbook on gears, it is the tensile fillet from which all fatigue failures originate.

On the question of fatigue endurance of gears, the author is to be commended on the information which he has collected and collated on this subject. Much, however, depends upon the application and the industry concerned. For example, aero-engine gears and automobile gears are entirely different applications, both from the point of view of materials, heat-treatment, finish, production techniques and operating conditions. The stress engineer, however, tackles the problem in much the same way by realising that it is impossible to take into account all the variables, and having decided on a method of stressing builds up a body of comparative data of the different applications with similar conditions of operation and production. These figures are then correlated with failures on type tests with aero-engines and alternatively endurance runs in the automobile. Fatigue tests on small specimens of different materials often show a promising development which can then be tried on the actual job. The figures of bending stress obtained on the gear application are recognised as purely relative and not absolute values, but do serve a very useful and practical purpose in guiding the designer when a higher power engine of the same basic type is contemplated. If it is known, for example, to have a larger resonant torsional oscillation, a tentative allowance can be made for this factor.

With regard to stress concentration, the fact that stress concentration at the fillet radii is not taken into account in evaluating the bending strength factors of the B.S. No. 436, is not considered serious in view of the existing knowledge of the subject at the time this standard was prepared. The range of stress concentration at the fillets with existing quantity production tolerances may be con-

* Senior research investigator on transmission, Austin and Co., Ltd., Birmingham. (Formerly in charge of vibration and stress analysis, diesel engine design office, Blackstone and Co., Ltd., Stamford, Lincs.).

siderable, and the worst cases must generally be catered for if 100 per cent inspection is to be avoided.

Mr. R. J. Love : I should like to refer to the expression given on page 12 of the paper for estimating the limiting stresses for carburised gears. It is implied from this expression that the limiting stresses are influenced by the strength of the core material, but I do not think that the experimental evidence, on which the author's expression is based, can support this.

The author has referred to the weakening effect that may result from grinding carburised gears. In tests involving good commercial grinding, and involving the grinding of tooth roots, reductions of bending fatigue strength were very marked and variable, being 30 per cent, 35 per cent and 50 per cent, for three nominally similar gears ground by one method, and an average of 35 per cent for three gears ground by another method. From this there is, of course, a strong recommendation to use grinding methods which involve grinding only the working flanks of the teeth.

I consider that the author is in some difficulty when he attempts to assess the level of stresses to be allowed in gear design. Many would disagree, for example, that the influence of surface condition on gear teeth strength can be deduced from work on rotating-beam specimens, without reference to such matters as size effect, stress gradient or residual stresses. To make allowances for the influence of variable loading is particularly difficult from the present state of knowledge on the subject of fatigue. The very valuable work which has been done on photo-elastic models will certainly assist in the design of stronger tooth forms and must lead to an increase of accuracy in gear design. However, it would appear that the allowable stresses to be used in conjunction with the author's method of stress determination can only be determined with reasonable accuracy from service experience and laboratory tests on actual gears produced under commercial conditions.

Mr. H. P. Dancocks : Mr. Jacobson in his opening remarks anticipated my first comments and, in view of Dr. Merritt's contribution, it is with great trepidation that I range myself with Mr. Jacobson and reiterate what he said regarding the use of stress concentration factors, namely, that unless stress is accurately and easily computed, the use of the stress concentration factor does not seem to be fundamentally sound. Nevertheless, the stress concentration factor does exist in the fillet of gear teeth, and the author's factors may still give conservative results when used with bending fatigue test data due to the sensitivity index of engineering materials. I should like the author to extend further his remarks regarding the adoption of finer pitch gears and their attendant advantages, because it does not seem to me at first sight that these advantages are in fact obtainable. For example, using finer pitch gears, I should imagine that actual cutter control would be more difficult. At first sight it appears that the proposed new strength factors merely necessitated using stepped-up stresses to restore the *status quo* ; but the range of percentage differences given in Table I between the proposed values and B.S. 436 converted values show that this is not so.

Professor W. A. Tuplin : I think perhaps that I ought to point out at the start that for a great majority of gears this question of bending strength is not critical, or need not be critical. Apart from gears made from case-hardened steel, it is almost always possible so to design them that strength as limited by bending stress is not a limitation at all. At present the most widely used means of assessing strength factors is that which appears in B.S. 436, but, of course, it is very restrictive. The strength factors there refer only to a series of arbitrary calculations between the addenda of pinion and wheel, whereas we have been told repeatedly over the last fifty years that the generated involute system is very adaptable. You can do a great range of things with it but the B.S. specification does not suggest that. It does, by confining itself to arbitrary addenda proportions, suggest that there is some special virtue in those proportions and it would deter the newcomer to the subject from thinking that he could safely depart from them. Why does it do so ? Possibly it is because in producing the present gear chart a great deal of work was required in working it out, and I do not suppose that anyone would have taken on himself the task of working out all the corresponding factors for all possible combinations of tooth and addenda proportions which the adaptability of the system does present.

Coming back to the labour involved in presenting a really universal strength factor chart, the labour involved frightened off those who produced the B.S. chart, but Mr. Jacobson did not accept any similar limitation to personal inconvenience in undertaking his work. The number of factors which he has considered is very large, but even so it is much smaller than the possible number of combinations. Consequently it is inevitable that in order to obtain the strength factors for any combination which can be used, even from Mr. Jacobson's comprehensive work, it is necessary to use interpolation. In the British Standards Specification even on its restrictive basis it is necessary to use interpolation. You cannot read off every calculation. The full adaptability of the involute system is not normally used by many people because the methods of using it are not very well presented. One excuse for not using it is the fact that the only available strength factors do not apply to one restricted use. Mr. Jacobson's paper has gone a long way towards removing that excuse, and it would be of interest to find what excuse will be produced now in favour of it.

With regard to the stress concentration factor, if you want a definition it is the ratio of the actual stress to that calculated by some nice, easy, convenient but inaccurate method ! If we examine Mr. Jacobson's figures and compare them with the British Standard, there is no common ratio between them. Mr. Jacobson takes a number of examples in his paper and for one material he suggests a basic allowable stress of 51,000 lb per square inch, and if you look up the British Standards Specification you will find that it is about two-thirds of that. So we can conclude by saying that we can use Mr. Jacobson's strength factors in a formula for the load carrying capacity of gears on the basis of bending strength if you multiply by the factor of $1\frac{1}{2}$. If you do that, the author's method will line up pretty well with what the British Standards Specification gives for its own particular field, but Mr. Jacobson's method covers a much wider field as well.

Mr. S. L. Harris : I have been particularly interested in the paper, because for some time we have been working at Cambridge on dynamic stresses in gear teeth using a photo-elastic technique. We have found that the actual forces between the teeth vary so widely that we found it necessary to leave consideration of fillet stresses on one side, and concentrate on analysing the factors that give rise to maximum tooth contact forces. The author's results will undoubtedly be most useful in the future when more is known about tooth loadings. The author suggests analysing the contact stresses. As these are almost certainly Hertzian stresses with an occasional unknown tangential component, I am doubtful whether their analysis would serve any purpose. The author also suggests that the maximum tooth load will occur at the end of single tooth contact. This is only true when the teeth are perfect, as the point at which maximum static tooth loading takes place will be governed by pitch and profile errors. So it is not as simple as doing graphics and saying where the last point of single-tooth contact will occur. An error of 0·001in will throw it out a long way. With regard to dynamic tooth loads, the author suggests that their cause will be either pitch errors or torsional vibrations, and I suggest that this may be an over-simplification. It is not sufficient to know the maximum error to be able to find the maximum tooth force.

Mr. M. L. Meyer : Improved gear design for strength would demand answers to three questions. The first is given a tooth shape and loading, what is the peak tensile fillet stress ? Secondly, what is the actual instantaneous loading as the teeth traverse the zone of contact, and thirdly, how can the ensuing actual peak fillet stress be evaluated in terms of the fatigue strength of the finished component ? In all three answers, a compromise must be made between the demands for accuracy of the answer and for comprehensiveness and simplicity of a resulting formula or graph. The importance of the paper lies in its answer to the first question.

The author's approach to an interpretation of fatigue data is very valuable for its comprehensiveness at the present stage of knowledge. However, he has to rely on admittedly vague service factors and it is unlikely that this fundamental limitation can be overcome until more is known of fatigue under actual service conditions, or conditions approaching them. After all, even tests on standard specimens are only " qualitative " in the sense that they compare different materials under identical conditions, and the service factors simply mask this unsatisfactory state. There is one point on which the author's investigations may give valuable information. Fatigue very sensitively seeks out the actual point of peak stress and a crack, once started, usually follows the maximum stress gradient. Do actual tooth failures confirm the photo-elastic picture in this respect ? Is the difference between the photo-elastic pattern and the geometrical assumptions underlying the Lewis formula sufficiently pronounced to indicate which method gives the more realistic approach, and lastly, does the point of maximum fillet stress shift with a change in the position of the point of contact on any given tooth ?

(*To be continued*)

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.—The North of Scotland Hydro-Electric Board has published the Tummel-Garry Project (Amendments), Constructional Scheme No. 2A, covering the construction of a small power station in Glen Errochty, in Perthshire, which will add 1,750,000 units of electricity yearly to the estimated annual production of 300 million units of the Tummel-Garry Scheme. Under the Tummel-Garry Scheme, the Board is required to provide compensation water from the Errochty dam to give a minimum flow in the River Errochty and it is proposed to use this water to produce power. The scheme includes the erection of an aqueduct from the reservoir in Glen Errochty to a power station to be built just below the falls on the Errochty Water near Trinafour, with a tailrace to the Errochty Water. The station will have a capacity of 550kW.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. 1

THE evening of Monday, April 4th, marked the opening of the annual spring meeting of the Institution of Naval Architects, which this year was held at 10, Upper Belgrave Street, London, S.W.1, the headquarters of the Institution. For many years the annual meeting has been held elsewhere in London, but owing to the completion of the long-delayed building scheme, which includes a lecture hall, it has been possible to hold such a gathering at headquarters.

Viscount Runciman of Doxford formally declared the Weir Lecture Hall open. In the course of his remarks he commented upon the prudent financial policy of the Institution which had made the reconstruction scheme a possibility, and the generous gift of Lord Weir, which greatly facilitated the building of the hall. The president expressed the thanks of the Institution to those who took part in the building work and also to those who made gifts towards the furnishing of the room. He went on to say that the hall was designed for use and that the justification for its existence would be the purpose to which it was put in furthering the advancement of the art and science of shipbuilding.

Weir Lecture Hall in the headquarters of the Institution of Naval Architects

The lecture hall, which we illustrate, has been built on the site of a house which was destroyed during the war and which was acquired, together with the premises now forming the headquarters of the Institution of Naval Architects. Plans were considered in 1946 for the repairing of war damage, and in 1950 a scheme incorporating replanned accommodation and a lecture hall was approved. In 1953 Viscount Weir of Eastwood made a generous donation of £10,000 to the Institution, and in the same year a licence to build was granted so that it was possible to put the work in hand. The hall has a seating capacity of 142 and there is a small annexe, with space for an additional thirty-six seats. Abura wood has been used for the panelling of the walls and is relieved with bands of sycamore and on the dais are the president's chair and two flanking chairs of bleached mahogany and upholstered in blue leather, as are all the chairs in the main hall. As a background to the dais, which has a centre panel carved with a representation of a grant of Arms to the Institution, is a fabric panel symbolising the wide range of products of the shipbuilders art, and this is flanked by stone panels, one representing science in shipbuilding, and the other representing the art of ship construction. There is a concealed screen, together with other equipment for the showing of films, and there is a panel on the dais for the control of lighting, heating and ventilation. At the entrance, a small teak panel commemorates the gift and the opening ceremony, and in the lobby is an illuminated globe of the world.

At the conclusion of the opening ceremony, the first Amos Ayre Lecture, which had been written by the late Sir Maurice E. Denny, Bt., under the title, "The Man and His Work," was presented by Edward L. Denny, his cousin and present chairman of William Denny and Brothers, Ltd. As the title implied, the lecture, which we summarise below, was concerned with the work and activities of Sir Amos Ayre in the service of the shipbuilding industry. His early training and his duties in the first world war were noted and also the founding of the Burntisland Shipbuilding Company in conjunction with his brother in 1918. Some six years later he began to participate in the general affairs of the industry, and in 1930 became president of the Shipbuilding Employers' Federation. The lecture showed that Sir Amos was concerned with affairs covering a wide field extending beyond the industry itself. It touched upon his efforts during the years when the industry was struggling for economic survival. Brief details were given of the many and varied activities in which Sir Amos was engaged at the time and which gave him scope to develop his gift for administration, his liking for statistics and the use of his technical knowledge and experience. All these engagements in affairs outside his private business stood him in good stead when he accepted, in 1936, the invitation to become chairman of the Shipbuilding Conference. This move caused Ayre to relinquish direct participation in shipbuilding to become, what was described in the paper as the senior civil servant of the industry. His work in the years immediately preceding the second world war was reviewed, and also his activities as director of merchant shipbuilding during the war, activities which were concerned with the development of steel fabrication and the planning for ship production at home and in the U.S.A. In the post-war period, Ayre was interested in the question of the efficiency of the shipyards, and gave encouragement to modernisation schemes, and the lecture went on to mention his efforts in the drive for increased exports and his advocacy for collective research by the industry. Amos Ayre was actively interested in the work of the British Shipbuilding Research Association and of the Admiralty Ship Welding Committee, and the paper recalled that he had contributed largely to the transactions of many technical societies, one of his particular subjects being the powering of ships.

The appraisal of Ayre's technical papers included extracts from one of his addresses, which illustrated his attitude to technical education, and the lecture concluded by stating that Amos Ayre was acknowledged as being one of his generation's outstanding shipbuilders, and recording the many honours with which his services had been recognised.

Sir James McNeill expressed the thanks of the Shipbuilding Conference to Mr. Edward Denny, and recalled that the Amos Ayre Lecture, established to perpetuate the memory of Sir Amos Ayre and his services to shipbuilding, was to be delivered at intervals of three years. The present paper inaugurated the series and, he said, left the way open for subsequent lecturers to write papers upon the subjects which had interested Sir Amos Ayre.

(*To be continued*)

Technical Reports

Structural Trials on S.S. "Ocean Vulcan" and S.S. "Clan Alpine"—Report No. R12—Discussion of Results. The Admiralty Ship Welding Committee. H.M.S.O., 1954. Price £1 5s.—The trials of the almost wholly welded S.S. "Ocean Vulcan" and the S.S. "Clan Alpine," which is mainly riveted, were conducted as part of the general investigation of the relative structural behaviour of welded and riveted ships. For reasons given in Report R.8 it was considered impracticable to take the direct measurement of the stresses in the ships' structures while at sea, and an indirect approach was adopted in which the trials were divided into two parts. First, the still water stresses and deflections were measured on each ship, both ships being of almost identical form and dimensions, the changes of stress and deflection being imposed mainly by controlled and calculable changes of longitudinal bending moment. From the results, stresses at various points and the overall deflection of both ships were derived for certain arbitrary standard values of bending moments.

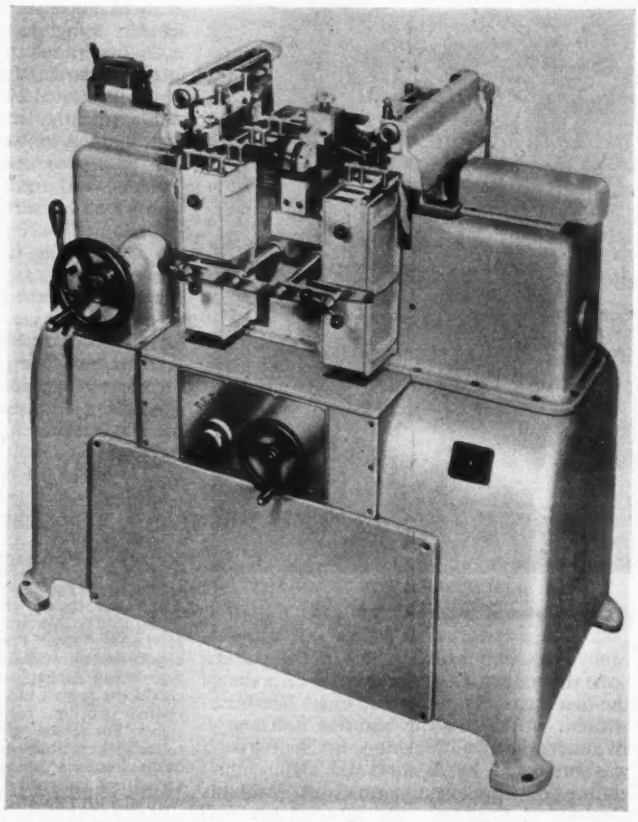
So that the bending moments and other actions, encountered by these ships at sea, could be determined the "Ocean Vulcan" was equipped with necessary instruments and the second part of the trial carried out at sea. The results of the two parts of the trial are summarised in the report, separate sections dealing with the still water trials and the trials at sea, and by correlation of both sets of trials it shows the probable magnitudes of the stresses and deflections in both ships under severe service conditions. The investigation confirms the findings of earlier experiments which indicated that the differences in structural behaviour between welded and riveted ships are secondary in character and are due mainly to differences in design rather than to the structure as a whole. After making due allowance for local inequalities it was found that the distribution of longitudinal stresses in both ships was similar and in general agreement with the beam theory.

Transformer Lamination Assembling Machine

DEMONSTRATIONS are being given at the works of the Automatic Coil Winder and Electrical Equipment Company, Ltd., 92–96, Vauxhall Bridge Road, London, S.W.1, of a machine which automatically assembles laminations in transformers. This machine is of Continental design and the firm has acquired the selling and manufacturing rights. The machine handles E- and I-laminations from 0·008in to 0·032in thick, and it is made in two sizes for laminations between 2·75in and 5·12in wide and between 2in and 4·37in wide. Providing the laminations are of reasonably constant thickness and are of a kind of iron easily lifted by permanent magnets, it is possible to pack a transformer coil fully so that there is no need to insert any further laminations by hand. At normal machine speed it is possible to insert up to eighty-eight laminations a minute in a transformer coil.

The general arrangement of the machine can be seen in the accompanying illustration. It is driven through reduction gearing and belts by a 1 h.p. motor in the lower part of the cabinet base, and all the movements are controlled through a main camshaft which runs across the full width of the machine. For the mechanical operation of lamination insertion the coil is fitted with a special guide plate and then placed in a recess in the centre of the table of the machine. When a clamping arm is then swung over and locked in position the coil is pressed down against the spring-loaded base of the recess to set the guide plate in line with longitudinal slideways extending to the right and the left along the length of the table.

The pairs of E- and I-laminations are stored in four special containers, one container being set adjacent to each end of two bridges extending across the width of the machine on each side of the coil clamping station. In operation the laminations are picked up from each of the four containers and inserted in turn into the coil. The laminations are picked up from the containers by sets of permanent magnets extending down from a plunger mechanism mounted on a reciprocating slide on each bridge. Each slide is fitted with two sets of pick-up magnets, and as it shuttles back and forth across the width of the machine it picks up an E- and an I-lamination from the containers at the back and the front of the machine at each stroke.



Machine for automatically assembling laminations in transformer coils

When the two laminations on the pick-up magnets at one end of a slide reach the centre of the machine there is a short dwell period whilst a shaft along the top of the bridge is turned through a few degrees. Links extending from this shaft push the spring-loaded magnet assemblies downwards. At the bottom of this stroke the laminations are pulled off the pick-up magnets by a set of slightly more powerful magnets in the main longitudinal slideway. Simultaneously the pick-up magnets at the other end of the feed slide contact the E- and I-lamination in the container at the other side of the machine. The magnet assemblies then rise and the slide is ready for the next cross movement to bring a set of laminations over the longitudinal slide on one set of pick-up magnets and position the opposite magnets over the other container.

As the pick-up magnets are raised the set of laminations deposited in the main longitudinal slideway is contacted from the rear by a pusher block actuated through an arm and lever mechanism at the end of the table. This pusher block slides the laminations along guide ways into the transformer coil, the E-lamination entering first, followed by the I-lamination. The I-lamination is pushed in below the rear part of the E-piece, which is held up by springs in the base of the slideway. At the end of the insertion stroke the pusher arm is retracted at high speed.

This sequence of operations is effected from both ends of the machine and the timing is such that successive laminations are picked up and fed into the coil from each of the four containers. The camshaft control of the mechanical linkage ensures that each sequence of lamination insertion is completed before another movement starts and a slipping clutch in the drive prevents damage to any component parts should a lamination jam. By working with laminations supplied from four individual containers no time is lost in return movements of the pick-up slides on the bridges. It will be seen that as one set of laminations is being picked up at one end of the machine a second set on the same slide is being deposited; at the same time a set of laminations is being inserted in the coil from the other end, whilst that slide is traversing across to the pick-up and depositing station.

As the laminations are removed from the containers the stack is automatically raised by the thickness of one lamination at each stroke through a rack and pinion mechanism. This mechanism is preset according to the thickness of the laminations by movement of a pointer over a graduated plate on the front of the machine. A handwheel on one side at the front of the machine can be used to operate it at slow speed when setting.

A preset revolution counter is fitted and through it the machine is automatically stopped when the required number of laminations has been inserted. In order to keep the mechanism in continuous operation spare sets of containers can be loaded with laminations whilst it is working. When one set of containers is empty it can quickly be removed by the unlocking of quick-acting hinged clamps and replaced by the second set. All of the guides of the machine are adjustable to suit the size of the laminations being handled, and for each size of lamination the machine has to be fitted with appropriate containers, pick-up magnets, bridge pieces and coil holder.

Erne Drainage and Hydro-Electric Scheme

SHORTLY after the outbreak of war the Electricity Supply Board in the Irish Republic developed a scheme for generating electricity in the portion of the Erne which flows through County Donegal (Irish Republic). The Board was aware that its scheme could be considerably supplemented if it could draw off a greater flow of water from Lower Lough Erne (Northern Ireland) and it was therefore suggested to the Northern Ireland Government that the Board would pay for the widening and deepening of the outfall channel from Lower Lough Erne. The fall in the river channel in Northern Ireland is so small as to make hydro-electric development in Fermanagh out of the question. The shouldering by the Electricity Supply Board of the cost of widening and deepening the outfall channel enabled a drainage scheme to be carried out at a cost which was not prohibitive.

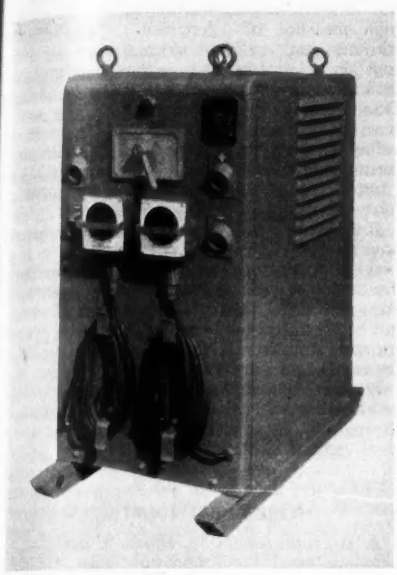
The works being carried out at the expense of the Electricity Supply Board are, in the main, the deepening and widening of the river channel between Rosscor and Belleek, the construction of a new road bridge at Belleek to replace the existing bridge (which is a serious obstruction to the flow of water), the construction of a barrage with sluices and navigation lock downstream of Enniskillen, the removal of the barrage and sluices at Belleek, the underpinning of Rosscor viaduct and other necessary incidental works. The Act authorising this work also permitted the carrying out of a scheme for improving drainage, commonly referred to as the "Summer relief scheme," for its object is to prevent, as far as is possible, any flooding around Upper Lough Erne during the growing season—April to September.

The work of widening and deepening the outfall channel is expected to be substantially completed by about the end of next September. Work under the contract for the new road bridge at Belleek was commenced in January, 1954, and is timed for completion in November of this year. The underpinning of Rosscor viaduct will be completed in a few months' time. The contract for the construction of the new barrage at Portora was let in July, 1953, and is due for completion in January, 1956. Under the Summer relief drainage scheme about 500,000 cubic yards of material (some of which is rock) has to be removed from the inter-lough channels, a new bridge has to be built to replace the existing Carry Road bridge, and underpinning works have to be carried out at West Bridge, Enniskillen. The Carry bridge contract was let in May, 1954, and is due for completion in July, 1956. The inter-lough dredging contract was placed in December, 1954, and should be completed about September, 1957. It is estimated that the works being carried out at the expense of the Electricity Supply Board will cost over £1,500,000 and that the Summer relief drainage scheme will cost over £500,000.

WATER SOFTENING AND CORROSION PREVENTION.—A leaflet has been issued by Albright and Wilson, Ltd., 49, Park Lane, London, W.1, explaining the application of "Micromet" in order to prevent scale formation and rust in the smaller kinds of system such as diesel engine coolers, air conditioning plant and certain refrigerating circuits. "Micromet" is a slowly soluble metaphosphate which is added by means of the simple arrangements described to the extent of a few parts per million.

Transformer-Rectifier Power Unit for Welding

A TRANSFORMER-RECTIFIER power unit that has been developed by Crompton Parkinson, Ltd., Aldwych, London, W.C.2, for stud welding and manual arc welding is illustrated here. It provides a choice of three outputs—one for stud welding up to ½in diameter studs—another for single operator arc welding with current up to 400A, and a third for two independent arc



Transformer-rectifier power unit for stud welding and arc welding

welding operators using up to 200A each. The required output is rapidly selected by means of a three-position switch and facilities are provided for independent remote control of arc welding currents. The new equipment thus avoids the need for providing separate power sources for stud welding and arc welding, or for making cumbersome adaptations to stud welding power sources so that they may be employed to a limited extent for arc welding.

The new power pack consists basically of a three-phase, air-cooled transformer, which is suitable for input voltages of 210/250V and 360/440V and for operation on a 40 to 100 c/s supply; two banks of selenium rectifiers which can be operated either in parallel or independently, according to the position of the selector switch; and two magnetic amplifiers which facilitate fine control of current when the equipment is used for arc welding. The latter facility, in conjunction with two continuously variable rheostats connected by 20ft of cable, enables the operator to make accurate adjustment of the current at the point of welding.

Cooling is effected by a totally enclosed fan; if the fan motor stops for any reason a centrifugally operated switch interrupts the exciter supply, thereby reducing the output to a safe level.

An important characteristic of this equipment is the so-called "hot start" whereby a 25 per cent current increase occurs momentarily at the start of arc welding and provides for easy striking of the arc. Its current recovery time is comparable with that of an arc welding transformer.

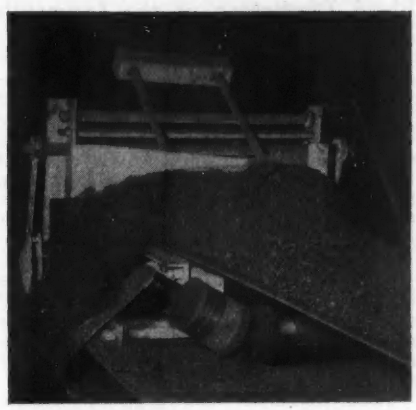
All components are contained in a rust-proof metal housing and have been designed to operate in both tropical and arctic conditions. It is 4ft high, 3ft 10in deep and 2ft ¼in wide, and the gross weight is 11½ cwt. Provision is made for remote control and, therefore, it is not necessary to have this power pack close to the point of welding.

Plough for Troughed Conveyor Belts

PARTICULARS have been received of a plough for use on troughed conveyor belts which is stated to overcome certain disadvantages encountered with throw-off carriages or trippers in removing materials from belts at points along their length. The device was developed by Commander J. H. Middleton, R.N. (Retd.), for installation at a number of points along a conveyor system handling two or more different materials. It is relatively cheap and simple to install and is stated to eliminate the time required in repositioning self-propelled trippers on a long belt and it enables maintenance or repairs to be carried out whilst the conveyor remains in service.

The equipment, which can be seen in the accompanying illustrations, is of particularly simple construction and the design is based upon the plough or cut-off knife long used on flat band conveyors. It is known as the "rising table plough," and its operation depends upon the fact that a plough requires a flat surface upon which to work effectively. The table of the device is pivoted on four links below the conveyor belt, and through these links the table is raised to lift the moving belt above the level of the troughing idlers. When the links have raised the table sufficiently to bring the belt back to its normal flat shape, they pass over the top dead centre. At this setting the links contact a transverse stop and are automatically held there to maintain the table in its working position.

A plough assembly supported by side members above the belt is coupled to the table linkage so that as the table is raised the plough blade is brought down into contact with the surface of the belt. The weight of the ploughshare is counterbalanced so that it rests lightly on the belt, and its actual pressure on the belt is imparted by the load of the material being carried along on the belt. The degree of this pressure is controlled by the design of the links and the height

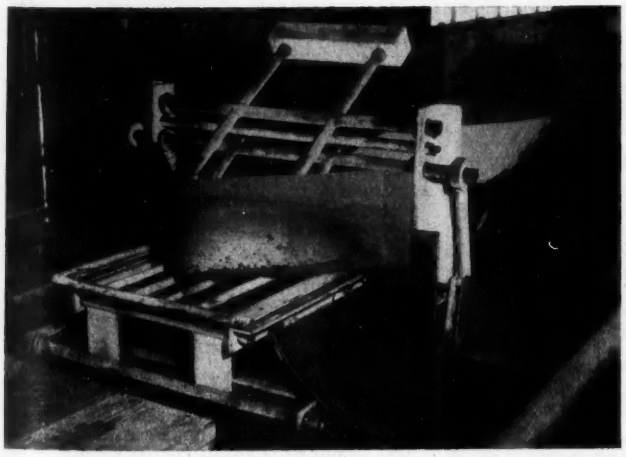


Plough in operation removing material from section of troughed belt raised and flattened by table

of the plough's axis above the belt. When the plough is not in use the blade is raised above the level of the material on the troughed belt, and the table lies below the bottom of the belt, so that neither touches it except in the working position.

The device is of straightforward welded construction except for the table, which is of cast iron, and in its assembly no close-fitting work is needed. In fact, enough play is given in all the links and shafts to permit the table and ploughshare to align themselves to the belt within reasonable limits. Only the ploughshare and the table are subjected to any wear and they are made easily detachable, by the removal of cotters, so that they can be turned over to present new working surfaces when necessary. The whole assembly can be removed from the conveyor by the removal of a few bolts and without affecting other discharge points. This only entails stopping the belt for about ten minutes. The lever mechanism is adaptable for operation by a hydraulic cylinder or similar means with remote control.

We are informed that twelve of these rising table ploughs have been in satisfactory service on a 24in troughed conveyor belt in a large chemical works for the past twelve months. This belt has been carrying 350 tons of graded coal and crushed ashes a day at a speed of 250ft per minute, and no trouble has been experienced with the equipment. After about six months the ploughs dealing with crushed ashes had worn down about ⅛in, leaving a step at the edge of the band track, and this step was ground off to avoid damage to the edge of the band. It has not been found that the use of the ploughs on a long belt increases the driving motor load significantly, provided that the ploughs are correcly adjusted. The ploughs normally work on a continuous jointless belt, but it has been proved by trial that they will ride over a "Mastarbar" band clip, so that this kind of fastening can be used for an emergency repair.



Rising table plough in working position with conveyor belt removed to show table assembly

Rising table plough in inoperative position with blade raised and table lowered

Flood Discharges in the Lynmouth Flood of August, 1952*

By C. H. DOBBIE, M.I.C.E., F.G.S.

CATASTROPHIC floods occurred on the night of August 15, 1952, in North Devon, when there was considerable loss of life and great damage was occasioned. The small seaside village of Lynmouth suffered the greatest damage. The hydraulics and hydrology received a comprehensive treatment by the author and P. O. Wolf in the paper "The Lynmouth Flood of August, 1952," Institution of Civil Engineers, May 28, 1953. One main point of discussion was the method of assessment of flow after the flood had passed. The present paper elaborates on this point in much greater detail than could be given in the original paper, which embraced so many aspects of the flood.

Flood discharges were calculated by the author's staff from actual measurements at twelve selected gauging sites. They were also calculated independently by P. O. Wolf from rainfall maps prepared by the Meteorological Office based on their rainfall measurements and observations of the area. Mr. Wolf's calculations gave maximum discharges as follows :—

East Lyn River, 13,000 cusec ; West Lyn River, 8000 to 8500 cusec ; from combined catchment area, 21,000 to 21,500 cusec.

At the twelve selected gauging sites, cross sections were taken, together with the mean slope of the river. The maximum depth was measured from the evidence left by the flood. Manning's formula was applied to these hydraulic data to arrive at discharges. A value of the roughness element of the formula "n" had to be selected for each cross section, and this was done by an engineer experienced in torrential river flow. With rivers as steep as 3 per cent or even greater and carrying boulders sometimes as big as 3ft cube (3ft by 3ft by 3ft) Manning's formula is more a useful device than the truly representative picture of flow that it is under less torrential conditions. Under torrential conditions, when velocities are critical or nearly critical, they are independent of slope and roughness. Manning's formula, however, is employed as a standard practice and so has many useful comparisons. The value of "n" was selected on experience, but as a guide the selector made various calculations as follows :—

(1) At gauging sites where the bed was formed of small and closely packed pebbles, the value of Chezy "C" was calculated by use of the formula quoted by Professor C. M. White :

$$C = 32 \log_{10}\left(13 \times \frac{d}{k}\right) \text{ft}^2 \text{ per second,}$$

where

d = mean depth in feet.

k = mean size of bed material in feet.

(2) At gauging sites with bed material formed by large loose boulders values of Chezy "C" were calculated from the formula quoted by Dr. Nemenyi, which is a variation of Prandtl's formula :

$$C = 32g \log_{10}\left(0{\cdot}4\frac{m}{k_1}\right),$$

where

m = hydraulic mean radius,

and

$k_1 = \frac{1}{10}k$, where k is the mean size of boulder.

In both these cases the value of "C" was then converted to a value of "n."

(3) At gauging sites where there was a measurable constriction the flow was checked by critical discharge formula :

$$\frac{A^3}{B} = \frac{\alpha Q^2}{g},$$

where

A = cross-sectional area.

B = width at water level.

α = coefficient of correction for variations of velocity from mean. Values of α were assumed to be between 1·2 and 1·5, dependent on the site. The value of "n" was calculated back from this critical velocity formula.

(4) As an additional check a formula quoted by Professor Jack Allen was employed, based on experiments on rows of concrete blocks which would be moved at certain velocities. The formula is :

$$\bar{v} = \frac{L}{l}\left[10{\cdot}0 - \frac{5300}{\left(32 + \frac{h}{l}\right)}\right]\sqrt{\frac{p' - p}{p}l}$$

where

$\bar{v}$ = mean velocity at section when the uniformly scattered concrete blocks just move.

L and l = dimensions of blocks in feet.

h = depth of water over blocks in feet.

p and p' = specific gravity of blocks (2·5) and water (1·0). Again "n" was calculated back from this discharge formula.

By comparing the results obtained from (1) and (2) and (3) and (4) a final value of "n" was selected for each gauging cross section. These values varied from 0·029 to 0·08. Prandtl's formula alone sometimes gave higher values of "n" approaching to 0·11. These values were decreased on the evidence of the other checks. The results for maximum discharge of the catchment areas were East Lyn River 14,700 cusec, West Lyn River 8900 cusec, and from the combined catchment area 23,600 cusec. So the discharges calculated from gauging site measurements were higher than those calculated from rainfall.

An independent additional check was provided by a model of a peculiar constriction on the West Lyn River not far above its confluence with the East Lyn River. This model, constructed by the author's staff, was investigated by P. O. Wolf at the Hawksley Hydraulics Laboratory, Imperial College, and was found to give a maximum flood discharge of 7800 cusec as compared with 8900 cusec by gauging stations and 8200 cusec by rainfall.

The model discharge is probably nearest to the actual discharge and indicates an overestimation by other methods of the order of 10 per cent. This indicated that the high "n" values derived from the Prandtl formula are frequently justified.

The author's results were later recalculated independently by E. S. Crump, Sir Claude Inglis and T. M. Prus-Chacinski. Mr. Crump employed Boussinesq's critical velocity formula :

$$v = \sqrt{gm}$$

and also G. Lacey's formula :

$$v = 16(m^{\frac{3}{4}}i^{\frac{1}{2}}) \text{ft per second,}$$

where

v = mean velocity.

m = hydraulic mean radius.

i = slope.

His calculations have shown values about 10 per cent less than the author's for most of the gauging sites, but his discharge figure for the combined catchment area of 24,000 cusec is higher.

The results from G. Lacey's formula show that it should not be applied to a torrent as it was expressly devised for regime channels.

Sir Claude Inglis also used Boussinesq's formula, confirming the results of Mr. Crump.

Mr. T. M. Prus-Chacinski recalculated all the cross sections employing Matakiewicz's formula :

$$v = 35{\cdot}4m^{0{\cdot}7}i^{(0{\cdot}493 - 10i)} \text{ metres per second.}$$

This formula was developed in Poland from very many measurements of the natural rivers and torrents, and although somewhat similar to G. Lacey's formula does not require the river to be in regime. It is unique in that when the slope exceeds 1·5 per cent there is no increase in discharge above the 1·5 per cent figures. The formula can be rewritten in the form,

$$v = \psi(m)\psi_1(i) \text{ metres per second,}$$

and can be solved by special tabulations or by nomograms.

Results of these calculations show discharges as East Lyn River 12,600 cusec, West Lyn River 8600 cusec, from combined catchment area 21,200 cusec, again lower than the author's original calculations. Summarised, the results can be shown in a table :

Formula or method used	Discharge of combined East and West Lyn River catchment areas in cusec
(1) Rainfall per P.O. Wolf	21,000–21,500
(2) Manning's formula-author	23,600
(3) Boussinesq's formula, E. S. Crump and Sir Claude Inglis	24,000
(4) Lacey's formula, E. S. Crump ...	28,700
(5) Matakiewicz's formula, T. M. Prus-Chacinski	21,200

The most striking feature of the table is the high measure of agreement. Matakiewicz's formula and rainfall calculations are close together at lesser values than the others, probably indicating the nearest values to the true discharge. Discharges by the Manning formula would have been nearer if the author had used higher value of "n" as shown by use of Prandtl's formula. In actual design, the figure of 25,000 cusec used allows some margin for an even greater intensity of rainfall in the catchment area.

It is possible to draw some general conclusions having useful application elsewhere :

(1) In steep torrents carrying large boulders, discharge can be calculated with reasonable accuracy either by using frictionless formulæ not based on regime rivers or by critical velocity formulæ which should include a correction factor for curvilinear velocity distribution.

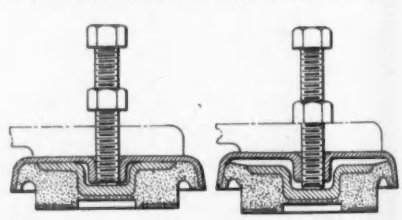
(2) If Manning's formula is used, good results can be obtained if the value of "n" is obtained through the use of Prandtl's formula.

* Abstract from a paper entitled "Methods of Assessment of Flood Discharges as Applied to the Lynmouth Floods of August, 1952," reproduced from the 1954 *Bulletin of the International Commission on Irrigation and Drainage.*

Machine Mountings

A MACHINE mounting, which is designed to eliminate need for foundation bolts, facilitate levelling on uneven floors, and isolate vibration, is made by Cementation (Muffelite), Ltd., 38, Victoria Street, London, S.W.1, in a number of sizes with load ratings from 70 lb to 2500 lb.

The arrangement of a typical mounting can be seen in the drawing reproduced below. It consists of an inverted cup-shaped, steel top cover member with a dished inner steel member, the two parts being attached together by a heavy block of bonded rubber. An annular ring of steel is bonded to the base of the rubber block, which is hollowed out in the centre. A hole in the centre of the cover is threaded for the reception of a bolt used for the attachment and levelling of the machine.



Arrangement of mounting before and after levelling a machine

Each foot of a machine is placed on a mounting and the bolt passed through the foot and screwed into the cover plate. As the bolt is then screwed down it contacts the recessed centre of the inner member of the mounting and raises the cover and machine. By further adjustment of the bolts the machine is levelled, and its full weight is transmitted through the rubber block to the annular support ring before the locking nuts on the bolts are screwed down. With this arrangement the machine is suspended on the rubber blocks, which serve to prevent vibration being transmitted from the machine to the surrounding floor area, or from the floor to the machine.

NATIONAL SMOKE ABATEMENT SOCIETY.—The National Smoke Abatement Society states that Lord Horder has accepted nomination as president to succeed Sir Ernest Smith next September. The Society's annual conference is to be held at Bournemouth from September 28th to 30th. During the conference the Des Voeux memorial lecture will be delivered by Dr. A. Parker, director of the Fuel Research Station on "The Destructive Effects of Air Pollution on Materials."

Combustion Equipment for Lancashire Boilers

We recently visited the dye works of J. Turnbull and Sons, at Hawick, where tests have recently been carried out by the National Industrial Fuel Efficiency Service on the company's Lancashire boilers, which have been fitted with the Ashworth system of balanced air draught. This system, which was introduced before the war, is made by Thomas Ashworth and Co., Ltd., Vulcan Works, Burnley. Our illustration shows a section of a fire tube to which the grate and blowing equipment of the system have been fitted.

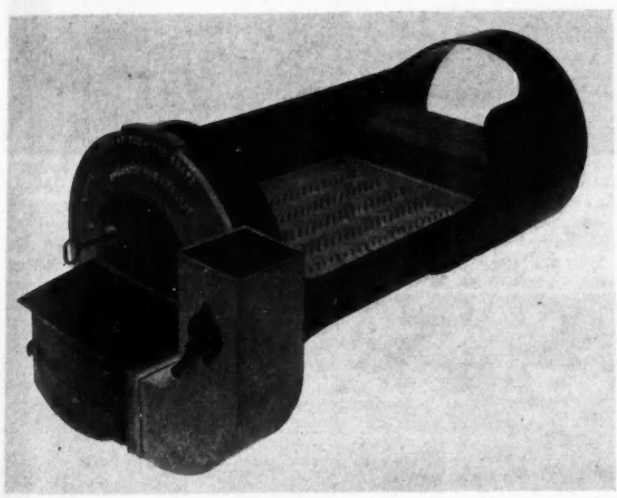
The improved efficiency of Lancashire boilers when using this equipment springs largely from the shape and orientation of the fire bars. These louvred fire bars are separate and interlock transversely with one another, the required spacing being obtained by integral lugs. They are supported only at their ends, which rest on side bars positioned by dead plates of special design. The geometry of the grate considerably increases the air space, improves the distribution and prolongs the life of the bars by virtue of their large surface area and more even temperature distribution. The bars do not stand vertically but are so sloped that the air meets the bed at about 45 deg.

The grate thereby operates with a very low air pressure and the main suction damper opening can be considerably reduced. This reduces the speed of the flue gases and allows the boiler to absorb more of the heat.

The principle of the balanced draught is an adjustment of the suction and pressure air dampers, with suitable instruments providing for reading of suction and pressure at any moment, and a quick "balancing" of the two by the fireman.

The supply duct to each furnace has a control damper to vary the air volume to meet steam requirements and is used in combination with the main suction damper to maintain a balance over the fuel bed. When the draught is "balanced," cold air infiltration is considerably minimised.

Provision is made for a secondary air supply over the fires. "Blow-back" is prevented by an automatic safety device. The balanced draught condition is made immediately obvious to the fireman by an 8in dial zero draught gauge which is connected to each furnace, and a freely swinging diaphragm.



Fire tube of Lancashire boiler, showing the special fire bars and blowing equipment

The report of the tests to which we have referred showed that the efficiency obtained was one of the highest measured on Lancashire boiler plant by N.I.F.E.S. survey teams. The boiler plant consists of two Lancashire boilers fitted with Holehouse stokers and the Ashworth system. A Green's economiser is installed behind the boilers.

Two boiler tests were carried out on similar steam loads of approximately 11,500 lb per hour, the first with both boilers sharing the load and the second with one boiler carrying nearly all the load, the second boiler being brought in for peaks only. The results, on gross calorific value of fuel as fired (11,637 B.Th.U. per pound) are as follows :—

	No. 1 Test	No. 2 Test
	Per cent	Per cent
Useful heat recovered by :		
(1) Boilers	69·3	63·1
(2) Economisers	9·9	10·1
Overall efficiency of plant	79·2	73·2
Evaporation from and at 212 deg. Fah., lb water/lb fuel	9·03	8·64

The dye company has also compared the coal consumption during the period of the installation of the system, May 17, to December 25, 1954, with the corresponding period of the previous year, the figures being :—

	May 16 to December 26, 1953	May 17 to December 25, 1954
Average weekly coal consumption, tons	50·35	44·5
Average weekly evaporation, pounds	82,738 (including jet steam)	81,640
Average weekly lb/water per lb/coal, pounds	6·95	8·29

This record indicates a fuel saving of 11·6 per cent. Conversion of existing plant, the company states, can be simply and quickly undertaken and it results in a minimum fuel saving of 10 per cent.

Chip-Breaking Twist Drills

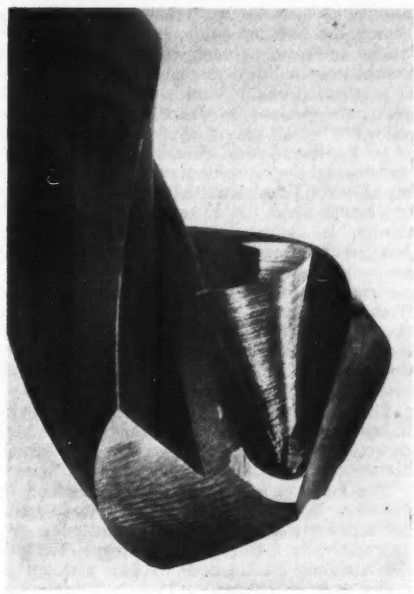
A NEW twist drill known as the "Chipbreaker," which has been developed by Firth Brown Tools, Ltd., Sheffield, is designed to increase cutting efficiency by chip control. It has a milled rib extending along the length of the flutes which gives the controlled chip-breaking action. Normal resharpening practice can be followed with the drills and, as the rib extends the full length of the flutes, the chip-breaking action is imparted throughout the life of the drill.

In introducing the drill, the makers point out that the usual methods of chip control practised for many years give serious limitations in that the width of the chip only is reduced by interruptions in the cutting edges of the drill. The length of the chip is not affected in any way and the resultant weakening of the cutting edges of the drill has restricted development of the principle.

With the new drill the chip is severed from the work along the full length of the cutting edge, and slides down the flutes towards the chip-breaker ribs, against which it curls and breaks off in short lengths. This rib imparts a tight curling action to the chip and, as the cutting edge is inclined at an angle to the chipbreaker rib, a shearing action is also imposed. The formation and controlled breaking of the chips resulting from the combination of these two factors can be seen in the photographs we reproduce.

By effectively breaking the chips, the drills make faster drilling times possible, particularly in deep hole horizontal drilling, where the number of withdrawals to clear a drill is reduced owing to the small size of the chips produced. The small chips also permit coolant to flow more freely to the point of the drill to give improved heat dissipation and drilling performance. A further advantage is that the long spiral swarf produced in drilling with standard drills is replaced by small chips which can be easily handled and transported, and the danger of flying swarf injuring operators is eliminated.

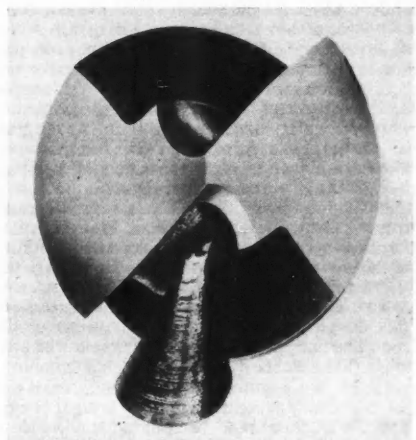
The makers do not claim that chip-breaking can be given on all materials and feed rates. Drilling at fine feeds per revolution on low tensile materials produces thin chips of high ductility which are passed along the flutes as a straight chip. When the point is correctly ground, ensuring equal length cutting edges and constant clearances, effective chip-breaking has been achieved employing 1in diameter "Speedicut Chipbreaker" drills drilling low tensile mild steel at feeds per revolution as low as 0·004in. The influence of correct point grinding is also shown by a marked improvement in the finish and size of the holes.



Chip curling by contact with rib in drill flute before breaking off

It is stated that the addition of the chipbreaker rib gives increased strength of section without detracting from the normal amount of flute space, so that the drill becomes more rigid in operation. Where conditions do not allow chip-breaking, this increased rigidity has been found to show a marked increase in the number of holes obtained per regrind.

At present, drills of the new design are being made in sizes from $\frac{3}{16}$in to $1\frac{1}{4}$in diameter, with Morse taper shanks Nos. 2 and 3, and other sizes will be introduced later.



Chip being formed at point of drill

Reinforced Concrete Bridges Constructed Since the War*

By W. A. FAIRHURST, M.I.Struct.E.†

I HAVE derived a great deal of enjoyment from studying numerous fine reinforced concrete bridges constructed in various parts of the world since the war, and in selecting from them six designs of special merit on which to comment. Unfortunately, due to the serious neglect by the authorities of roads and bridges in this country during the past ten years, not a single British bridge could be seriously considered even as a competitor for this distinction.

A selection of this kind is largely a matter of personal opinion, as there are no absolute values by which one can judge the finer points of bridge design, and I should even be a little disappointed if the majority of engineers agreed with my choice. I have omitted from the chosen six any bridge which did not appear to comply with reasonable æsthetic requirements, no matter how great the technical difficulties were in any particular design. Almost all the bridges did possess, in some degree, good lines and freedom from irrelevant and trivial ornament, but some of the bridges which otherwise showed great technical competence proved that all engineers have not yet learned their lesson from the many ugly bridge structures erected before 1939.

There has evidently been considerable activity in bridge building abroad, and the bridges I have chosen are representative of work in Switzerland, Germany, Brazil, Italy, France and the U.S.A.

The Gueuroz Bridge, which was designed by Professor A. Sarrasin, is illustrated here. This slender and graceful structure includes two amazingly slim arch ribs of 323ft span. The arch ribs are only 3ft 7in deep by 24in wide at the crown and 6ft 7in deep by 24in at the springing. Such small depths are only possible because of the deep parapet girders which act as stiffeners. The artistry of the bridge design is almost equalled by the following effective paragraph, which appeared as a description of the function of the parapets :

" To give the maximum security to vehicles solid parapets have been used. These serve as stiffeners in the arch ribs on the centre span."

The apology for the necessary depth of the stiffener girders serves to emphasise the achievement of the slender arches. It would have been almost impossible to provide the necessary overall stiffness required without beams of the depth used. Vertical posts of " T " section have been used to carry the deck structure, everything being done to increase the general slenderness.

This type of bridge is really a kind of inverted suspension bridge and requires very good workmanship from the contractor if the reinforcement is to be properly protected against the elements. The design carries on the tradition of the fine work done by Robert Maillart, and Switzerland can be very proud of having produced such a masterpiece. Elaborate centering was required, and great constructional difficulties had to be overcome by the contractors.

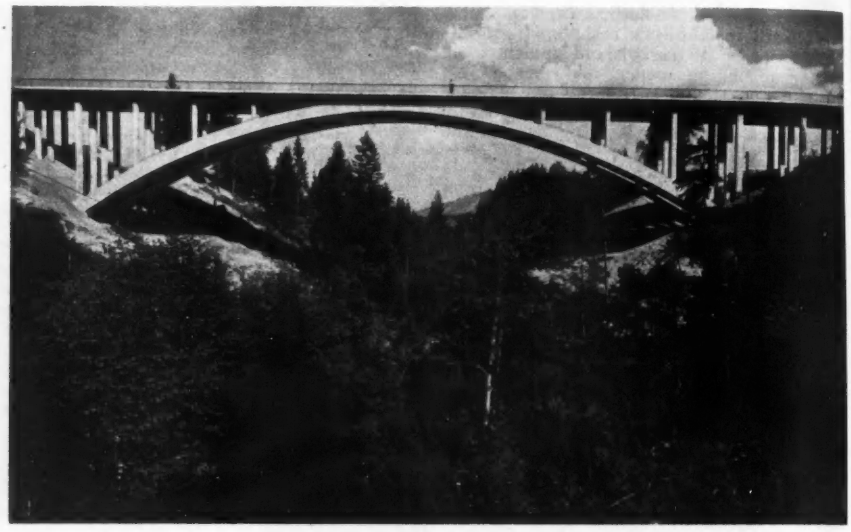
The bridge over the Tiefe Tal at Rosshaupten, Bavaria, is another bridge with a glorious setting and the design is a particularly pleasing one. Two arch ribs, of box section, span 255ft, with a rise of approximately 41ft. The beautiful arch ribs are surmounted by thin posts which carry the deck structure. A most effective yet simple design of metal railing completes a picture worthy of its wonderful background. As the arch is of parabolic form, even the foreshortened views look well. The construction of a bridge in a ravine of this kind is always a difficult job, and the design of the elaborate three-hinged truss used for the centering was, in itself, a fine engineering achievement. Jacks were built in at the crown to allow for the distortion due to the shortening of the arch.

Two of the principal features in the success of this design are the uninterrupted sweep of the road line and the graceful soffit curve of the arch ribs. The absence of distracting detail, combined with the two features just mentioned, make this an outstanding contribution to bridge design, and the engineer is to be congratulated, and so

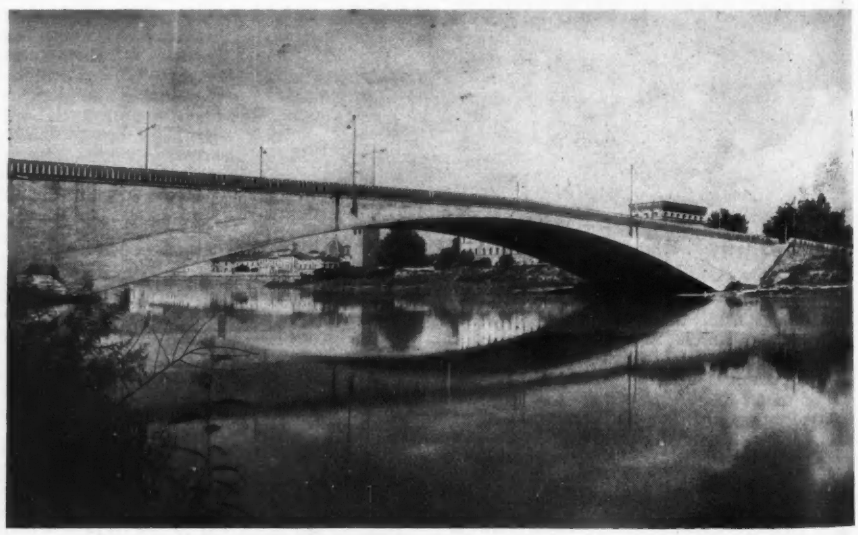
* Paper presented at the Pavings Development Group (Cement and Concrete Association) meeting at the Institution of Civil Engineers, Wednesday, March 30, 1955.

† Partner, F. A. Macdonald and Partners, consulting engineers.

Bridge at Gueuroz, Switzerland



Bridge at Rosshaupten, Germany



San Niccolo Bridge, Florence, Italy

Bridge on the Meuse, Liege, Belgium

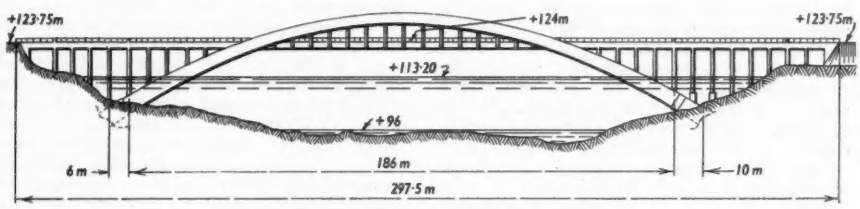
are the contractors for exceptionally good workmanship.

It is interesting to compare the Rosshaupten Bridge with the Gueuroz Bridge, and to observe the great difference in treatment of the two structures at deck level. In one case there is a light metal railing to increase the lightness of the deck construction (and let the motorist look after himself) and in the other case a solid parapet which, together with the depth of beam below deck, adds to the effect of lightness of the arch and vertical posts. It is difficult to say which of these two bridges is the greater masterpiece.

The bridge over the Rio das Antas, Brazil, is claimed to be the second largest reinforced concrete arch span in the world, and from our illustration it will be seen that nothing has been done in the design to detract from the grand beauty of the two great arch ribs. It is unfortunate and rather surprising that the longest arch span in the world, the Sandö Bridge in Sweden, which has a span of 866ft, has such a curiously unsatisfying appearance. Nothing can detract from the great technical achievement of constructing such a large span, but somehow the road line and the arch soffit line of the Sandö Bridge do not appear to harmonise.

In the present case the road line sweeps right across the valley and blends well with the two great arch ribs. The two arch ribs are hollow in cross-section, 9·84ft deep at the crown and 16·4ft deep at the springing, with a uniform width of 4·93ft. The arch ribs are at 28ft 6in centres. The posts supporting the decking are 23·6in square. The arch rise is 92ft, and the design and construction of the arch centering was a formidable undertaking. The arches are supposed to be of catenary form, which is satisfactory from an æsthetic standpoint for a high rise, even in the foreshortened view. All in all, a very fine achievement.

One of the flattest arches ever constructed was used in the San Niccolò Bridge, Florence. This bridge has a span of 303ft and a rise of 28ft 6in, giving a span/rise ratio of 11·4. The arch shape is parabolic, giving a satisfactory appearance from any angle. The crown thickness is 4ft 5in, and the springing thickness 11ft 8in, with a linear variation in thickness between crown and springing. The arch is of box section, with eight vertical stiffeners, each 9ft apart. The vertical ribs are joined by top and bottom slabs varying in thickness from 12in to 3ft 3in. The bridge has a width of 70ft. The abutments are of cellular construction and the whole design is full of interesting detail.



Elevation of Rio das Antas Bridge, Brazil

The third illustration on page 500 shows what a graceful structure this is, its beauty above road level being enhanced by a most original parapet design in concrete, which seems to harmonise with the top of the building which can be seen just across the river. It is unfortunate that some flaws in the concrete work are shown where the spandrel walls run into the arch slab. The problem of arranging lifts of concrete so that the lines of construction joints will not be unduly evident is always difficult, and many fine structures have been spoiled in this way. In the present case, we have a very fine bridge embodying splendid design and technical competence, and only minor faults detract slightly from its great merit.

The Jacques-Boulloche Bridge at Bezons (as illustrated at the foot of this page) is a girder bridge with beautiful soffit lines, which has a central span of 312ft and two side spans of 176ft. There is a hinge at the crown of the central span and rocker supports at the ends of the side spans and at the river piers. The ribs have a depth of 4ft 9in at the crown and approximately 26ft at the centre supports.

To avoid obstructing river traffic, an elaborate method of constructing the concrete box girders was required, using steel lattice girders spanning from the abutments to the central piers. The lattice girders were made of built-up sections bolted together with Bailey bridging. The reinforced concrete portions of the bridge over the piers were cast first and then used as supports for the lattice girders by means of joists, as the girders were launched from the bank to the central pier. Construction then proceeded simultaneously on the other side of the pier and, after portions of the concrete had hardened, the joists supporting the lattice girders were moved forward in order to shorten the span.

This bridge was a fine technical achievement in view of the foundation and construction difficulties, and its lines are extremely pleasing. It is unfortunate that the system of construction makes it exceedingly difficult to produce a fair face to the spandrel walls, and there is much to be said for using facing slabs to the spandrels, as was done in the case of Waterloo Bridge.

Squirrel Hill Viaduct, near Pittsburgh, is a pleasing example of a multi-span arch design. The three arch spans of approximately 180ft have a span/rise ratio of about 2.

This is a simple and graceful structure with a fine road line and beautifully delicate arches. The vertical posts are slender and there are no distracting details. In the past, many American bridges have been spoiled by massive pier construction over the centres of the arch supports, and in many cases the piers have been carried up to interrupt the sweep of the road line.

A notable bridge was completed in 1949 over the River Paraguay on the railway between Santos and Bolivia. It has a length of 6591ft, with a main arch span of 360ft, and is undoubtedly one of the major engineering works constructed in the past decade. In appearance, however, it is fussy, elaborate and unsatisfying. A great opportunity missed.

A bridge over the Meuse at Liège has a pleasing appearance, and the good lines of this city bridge are not spoiled by the elaborate sculpture on the cutwaters and approaches. It is illustrated above.

Amongst other interesting bridges almost worthy of a place in the first six are the bridge at Conflans-Fin-d'Oise, the bridge over the upper canal at Heilbronn and an arch bridge over the River Artuby, in France. It is a pity that Britain cannot provide even a runner-up, but let us hope that the position will be very different in a few years' time. Waterloo Bridge is worthy of comparison with almost all the masterpieces discussed here, and British engineers only need the opportunities to emulate their foreign contemporaries.

Jacques-Boulloche Bridge at Bezons, France

ALUMINIUM IN SHIPBUILDING.—We are informed by the Institute of Welding that a joint symposium on the Use and Welding of Aluminium in Shipbuilding is to be held in London at the Institution of Naval Architects on December 7th and 8th.

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

The seventeenth biannual report to Congress of the U.S. Atomic Energy Commission (A.E.C.) stresses the fact that an event of great significance during the latter half of 1954 *was the enactment of the Atomic Energy Act of* 1954, *which became law on August* 30*th, when President Eisenhower signed the Cole-Hickenlooper Bill. It is the first complete revision of the statutory charter of the Commission since the passage of the original legislation in* 1946. *The paramount objective of the A.E.C. has not been altered : to make the maximum contribution to the common defence and security. What is new is an added emphasis on the development of peaceful uses of atomic energy. Workable authority has now been provided to permit greater international co-operation, to increase the participation by private enterprise, and to assure an effective dissemination of both scientific and industrial information.*

IN its operations under the old law, the Atomic Energy Commission, in giving priority to its work on nuclear weapons, had not neglected the development of peacetime applications of atomic energy. The progress in the development of power and research reactors, the growth of the industrial participation programme, the remarkable expansion in the varied uses of radioactive isotopes and the continuous support of basic and applied research are evidences of the faith of the agency in the future of benign uses of the atom. The Atomic Energy Act of 1946 recognised that advances in the art would make revision of the basic statute necessary and desirable. The new law reflects the decision that this time has arrived.

Production of Uranium

To meet the projected uranium metal feed requirements, on October 12, 1954, the Commission announced an expansion of its facilities at Fernald, Ohio, and St. Louis, Missouri. An estimated 20,100,000 dollars will be expended to expand the Fernald feed material centre, which is operated by the National Lead Corporation. The existing refinery and metal plant capacity at St. Louis, which is operated by the Mallinckrodt Chemical Company, will be expanded at a cost of 6,500,000 dollars.

On November 11, 1954, the Commission signed a contract with the Mississippi Valley Generating Company providing for the delivery of 600MW of electric power to, or for, the account of the Commission. This contract was negotiated in compliance with a directive from the President to the Commission to make arrangements for the purchase of power from private sources in order to reduce, by the autumn of 1957, the existing commitments of the Tennessee Valley Authority to the A.E.C. The power supplied under the contract will be delivered to the T.V.A. near Memphis, Tennessee, and arrangements are being made with the T.V.A. for the delivery of an equivalent amount of power to A.E.C. installations at Paducah, Kentucky, and Oak Ridge, Tennessee. As power under this contract becomes available, the Commission plans to release the T.V.A. from a portion of its commitments under its existing contracts.

The capital investment of the United States in atomic energy facilities continued its steady growth, largely as a result of progress in the construction of new major facilities at Oak Ridge, Paducah, Portsmouth, Savannah River, and Hanford, and at December 31, 1954, was estimated to have risen to about 6200 million dollars. Except for production plant facilities at Portsmouth, and the expansion of process facilities at Oak Ridge, most of the major construction in the present programme is nearing completion, and activity has begun to taper off. The costs incurred for new plant and equipment amounted to 1220 million dollars during the fiscal year 1954, constituting a new peak for the atomic energy programme. During this period, A.E.C. construction costs accounted for about 3½ per cent of the American total construction volume.

Reactor Development

The Commission's programme of developing reactors for industrial and military power and for naval and aircraft propulsion progressed in several phases during the last six months of 1954. Ground was broken for the first American nuclear power plant, the first atomic submarine began its sea trials, and industry took an active interest in the field by investing private funds in a study of the peaceful applications of atomic energy. With the need and feasability of nuclear power already established, the Commission evolved a pattern for research and development from which it believes will come nuclear power plants that will compete with other sources of energy. During the past six months, an increasing number of American industrial firms invested their money in studies in the field of reactor technology. Several of these have shown an intense interest in the Commission's power demonstration reactor programme, under which the A.E.C. will consider bearing a portion of the expense of reactor plants "leading to the demonstration of the practical value of such facilities for industrial or commercial purposes." Each proposal from industry to build and operate power demonstration reactors under this programme will be evaluated on the basis of its contribution toward the development of economically competitive nuclear power, the cost to the A.E.C. in funds and materials, the relative risk assumed by the licensee in proportion to the amount of assistance requested of the A.E.C., the competence and responsibility of the licensee, and adequate assurances given by the licensee against abandonment of the project.

The first nuclear-powered submarine, the U.S.S. "Nautilus," was commissioned last September, and began its sea trials on January 17th. In addition to work on several reactors for underwater craft, plans are now under way for a nuclear power plant for a large surface vessel. The table herewith outlines the current programme of the A.E.C. for industrial nuclear power development.

Ground was broken for the construction of the first American civilian nuclear power plant at ceremonies held at Shippingport, Pennsylvania, near Pittsburgh, on September 6, 1954. Details of this plant and its pressurised water reactor were published in THE ENGINEER of October 1, 1954.

The boiling experiments conducted by the Argonne National Laboratory at the National Reactor Testing Station in 1953 were resumed in June, 1954, after some modification and reconditioning of the facility. One final short period "excursion" was performed on July 22nd. In this test, the power was allowed to rise to well over a million kilowatts in a tenth of a second. This "excursion" resulted in destruction of the reactor core and some associated equipment, a result which was recognised as a distinct possibility in planning this test. The conditions imposed for this "excursion" were much more severe than those which are expected to occur in any reasonably conceivable accident. During the summer of 1954, a second boiling reactor experimental installation was constructed at the National Reactor Testing Station a short distance from the original installation. This reactor, which began operation on October 19, 1954, was built to demonstrate the operational reliability of a boiling water system and is similar in construction, but operates at a higher power (6000kW of heat) and a higher pressure (300 lb per square inch) than the previous experiment. The prototype boiling water power reactor (EBWR) is proposed for construction at the Argonne National Laboratory. The reactor and power generating equipment will be housed in a gas-tight steel shell, having a volume of about 400,000 cubic feet. The reactor, which will operate at a power of about 20,000kW and generate 5000kW of electricity, will be light-water-moderated and cooled. The fuel elements are mostly natural uranium, with a few enriched elements being necessary to obtain criticality. The Allis-Chalmers Manufacturing Company was awarded a contract to design, develop, construct and install the power generating, heat transfer and special equipment for the power cycle. The contract specifies that the power system components to be developed will be leak-proof, which is desirable from an operating standpoint. Leak-proof systems are particularly important to the technology of boiling reactors using expensive heavy water instead of light water. It is hoped that this reactor power system will be producing experimental amounts of power by the end of 1956.

The first sodium-cooled, graphite-moderated reactor (SRE) in the United States is now under construction. Ground was cleared and foundations are being laid at the reactor site near Santa Susana, California. North American Aviation, Incorporated, is contributing 25 per cent of the estimated 10,000,000 dollars required for the project in accordance with a contract between the company and the Commission covering the period 1954–58. The sodium reactor experiment is being built to advance the technology of sodium-graphite systems and to aid in evaluating the economics of this reactor for power production. The SRE will be constructed underground, in a tank filled with liquid sodium, into

Development Programme for Civilian Power Reactors

Reactor concept	Name	Location	Scheduled completion date	Moderator	Coolant	Fuel	Heat output, kW	Electrical output, kW
Pressurised water	Pressurised water reactor (PWR)	Shippingport, Pa.	1957	Ordinary water	Ordinary water	Slightly enriched uranium	264,000	60,000
Boiling water	Experimental boiling water reactor (EBWR)	Argonne National Laboratory, nr. Chicago, Ill.	1956	Ordinary water	Ordinary water	Natural and highly-enriched uranium	20,000	5,000
Sodium graphite	Sodium reactor experiment (SRE)	Near Santa Susana, Calif.	1955	Graphite	Sodium	Slightly enriched uranium	20,000	None
Fast breeder	Experimental breeder reactor No. 2 (EBR No. 2)	Not selected	1958	None	Sodium	Uranium plutonium alloy	62,500	15,000
Homogeneous	Homogeneous reactor experiment No. 2 (HRE No. 2)	Oak Ridge National Laboratory, Tenn.	1955	Heavy water	Heavy water	Highly enriched uranium in UO_2SO_4 solution	5,000	300
	Homogeneous thorium reactor (HTR)	Not selected	1959	Heavy water	Heavy water	Highly enriched Uranium in UO_2SO_4 solution	65,000	16,000

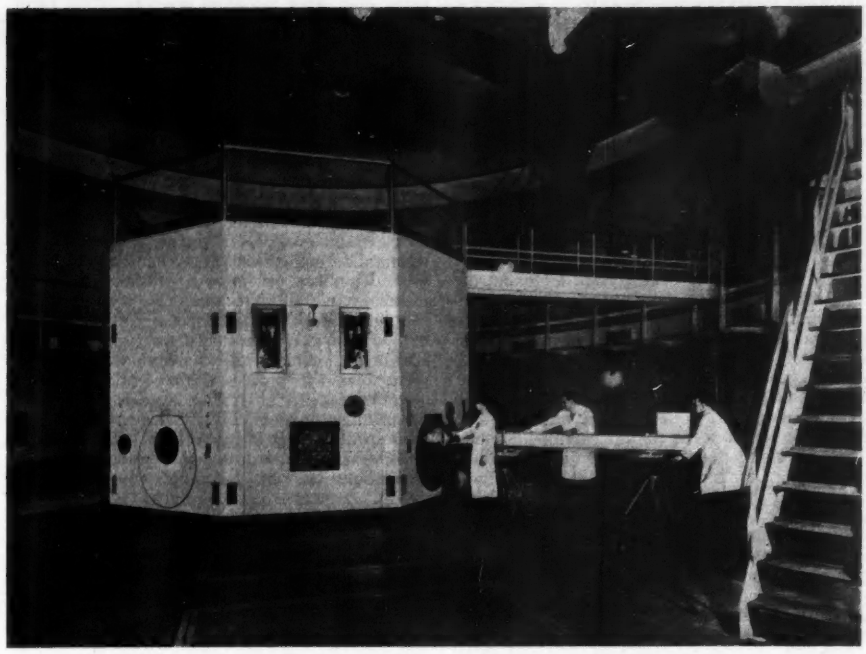
which columns of zirconium-canned graphite blocks will be placed to act as moderator. This design uses metallic fuel elements of either slightly enriched uranium or a combination of thorium and uranium.

The Commission has now entered the second phase in its development of homogeneous reactors with the construction of the homogeneous reactor experiment No. 2 (HRE No. 2) at the Oak Ridge National Laboratory. The first phase of the development programme was HRE No. 1, which was dismantled in the spring of 1954. In a homogeneous reactor, the fuel is dissolved in a liquid moderator and the entire solution is circulated as the coolant. Thus, this reactor more closely resembles a modern chemical plant than heterogeneous reactors in which fuel and moderator are separate. The HRE No. 2 is designed so that several homogeneous systems may be tested with comparatively minor modifications of the original reactor installation. The first experiment is intended to prove the basic component design, as well as the overall operational reliability and ease of maintenance. The HRE No. 2 is to be placed underground in a steel-lined reactor tank. The construction of this tank has been completed and the installation of the "low pressure system" is in progress. Contracts were awarded and fabrication started on all major equipment, including the heat exchangers, core tank, pressure vessel and circulating pumps. Experiments using an "in-pile loop" of circulating fuel simulating the conditions to be encountered in HRE No. 2 were successfully conducted in the low intensity test reactor at Oak Ridge. The third phase of the homogeneous programme is the medium-sized homogeneous thorium reactor (HTR). Development work on components for this reactor is now proceeding.

The development of reactors capable of producing more fissionable material than they consume remains an important objective of the reactor development programme. The operation of the experimental breeder reactor No. 1 (EBR No. 1), which went critical at the National Reactor Testing Station in Idaho in 1951, continues to contribute to the fast breeder programme. The first core of the EBR No. 1, consisting of enriched uranium, produced over 3 million kW of heat. The reactor is now operating on a second uranium core installed during the early months of 1954. A third core, this time made of plutonium, is scheduled to be loaded into the reactor during the first part of 1955. Breeding occurs in the blanket of natural uranium surrounding the core. The programme leading to the construction of a second considerably larger experimental breeder reactor (EBR No. 2) is now well advanced. The EBR No. 2, which is being developed and designed by the Argonne National Laboratory, will produce 62,500kW of heat and generate 15,000kW of electricity. The reactor will eventually be fuelled with a uranium-plutonium alloy with a blanket consisting of natural or depleted uranium. The present schedule calls for construction to start in 1955, and operation to begin in 1958. During the past six months experimental studies of sub-critical core assemblies for a fast breeder were carried on at the Argonne National Laboratory. Several hundred sets of measurements were made of the distribution of neutrons to be found in such sub-critical arrays of various compositions when neutrons from a source reactor are fed into them.

At the testing station in Idaho, the building to house the zero power fast reactor was completed. The critical assembly will begin operation soon, and will provide information on such factors as critical mass, breeding ratio, and power distribution in the core of EBR No. 2. A half-scale working model of EBR No. 2 was constructed at the Argonne National Laboratory to demonstrate the engineering feasability of the design, and this model began operation in March, 1955. An essential requirement for the development of a fast breeder reactor power plant is a facility for the fabrication of fuel elements containing plutonium. The design of the fuel fabrication building is nearing completion and its construction at the Argonne National Laboratory is scheduled to begin this year.

An industrial liaison branch has now been established in the reactor development division.



"CP-5" heavy-water-moderated, enriched uranium pile at the Argonne National Laboratory

This branch is charged with the responsibility of encouraging wider participation by industry in the peaceful application of atomic energy. The programme for industrial participation through study groups has also been broadened to allow a wider segment of industry to take advantage of the available technology. To expedite the peaceful uses of atomic energy, a new programme of access agreements permits industrial concerns to have individuals "cleared" to receive limited categories of information. Programmes of commercial activity and licensing are being developed to permit new companies and companies already in the programme to design, construct and operate reactors or related facilities. A comprehensive unclassified training programme in reactor technology is being developed. Present plans call for the establishment of an international school at the Argonne National Laboratory. The school began in March, 1955, with a four-month unclassified training programme in the broad fields of reactor technology, followed by a three-month session of applied engineering projects. The Oak Ridge School of Reactor Technology will continue with its classified training programme for recent university graduates and men from industry and the Government.

In December, 1954, a contract to design, build and test operate a prototype "package" nuclear power plant for military use was awarded to the American Locomotive Company. The plant—known as the army package power reactor (APPR)—will be built at Fort Belvoir, Virginia, which is the site of the U.S. Army Corps of Engineers Training Centre. It will be based on a design by the Oak Ridge National Laboratory of a pressurised light water reactor using enriched uranium fuel. Studies by the Army and the Commission established that such plants at remote bases would be technically feasible and have strong military advantages. For example, use of a power reactor plant, with components transportable by air, could reduce the amount of bulky conventional fuels

Control room of "CP-5" research reactor at the Argonne National Laboratory

that must be transported to support a military operation. In addition, a plant of this kind, which could be transported and erected anywhere in the world, should contribute to the objective of utilising atomic energy commercially.

The illustrations on the previous page show the "CP–5" research reactor which recently went into operation at the Argonne National Laboratory. This reactor may be regarded as a successor to those which have been in operation at this laboratory for the past decade; it is a heavy-water moderated, enriched uranium pile. In principle it is quite similar to its predecessor, "CP–3," but it has been designed for high specific power and, accordingly, for high neutron flux. The heavy water is contained in a right-cylindrical tank, about 6ft 6in in diameter, mounted vertically. The tank is pierced by horizontal beam holes, and vertical thimbles extend through the tank cover. Rectangular fuel assemblies, made of sandwiches of aluminium and uranium enriched with uranium 235, are grouped in the central part of the tank. Cooling water is pumped over the fuel assemblies at the rate of about 1200 gallons per minute. The critical mass of the reactor is about 1400 grammes; 7 tons of heavy water serve as primary coolant and as moderator.

Although the research reactor provides a wide variety of experimental facilities, it is necessary to follow procedures in their use which will assure the least interference with all experimenters using the reactor at the same time. To accomplish this the reactor will be operated at its normal power rating of 1000kW with as few shut-downs as possible. To provide irradiations of short duration for samples up to 1¼in diameter and 5½in long, certain facilities have been incorporated in the reactor which will allow the insertion and removal of sample materials or irradiation targets while the reactor is operating. Such facilities do not provide access to the highest flux regions of the reactor, but will permit samples to be placed in thermal neutron fluxes of about 10^9 to about 3×10^{12} per square centimetre per second. Smaller light-weight samples may be inserted and removed pneumatically for short irradiations in thermal neutron fluxes of about 1×10^{13} per square centimetre per second.

Irradiations in neutron fluxes ranging from 7×10^{12} to about 2×10^{13} per square centimetre per second may be obtained by placing materials in vertical thimbles which penetrate the reactor shield and reflector and terminate in the moderator adjacent to the reactor core. For the use of these facilities, the reactor must be shut down while inserting and removing the target material. Irradiation of irregularly shaped or larger targets may be accomplished in thermal neutron fluxes ranging from the order of 10^9 to 10^{13} per square centimetre per second by use of other facilities as they are available. These larger dimension facilities are chiefly for supplying neutron beams for a variety of experiments and their arrangements require the reactor to be shut down for insertion or removal of targets and other devices. The two "rabbit" holes of the reactor are useful in the study of elements with short half-lives and are pneumatically operated to make possible a rapid passage of samples into and out of the high flux region near the core.

Physical Research

During the past six months, cesium 137, which is a long-lived, gamma-ray-emitting fission product, was separated from irradiated reactor fuel at Oak Ridge and made into a large radiation source for a new teletherapy unit. The source, which is to be used for cancer research by the medical division of the Oak Ridge Institute of Nuclear Studies, is in the form of two small pellets about 1½in in diameter, ½in thick and weighing a little more than an ounce. Nevertheless, the source contains 1540 curies, equivalent to more than 20,000,000 dollars worth of radium.

A new facility capable of separating and purifying fission products for the production of large radioactive sources for industrial, medical and other uses has now been approved for construction at Oak Ridge. The new plant will greatly expand the "hot chemistry" facilities in the radioactive isotope programme of the Commission. It will provide equipment for separating and purifying kilocurie quantities of important long-lived fission products and for fabricating them into large radiation sources. The plant will have capacity for the separation of 200,000 curies per year of cesium 137, as well as large quantities of strontium 90, which is a valuable source of beta radiation. The fabrication facilities will be capable of producing single radiation sources containing approximately 2000 curies each, with provisions for combining two or more 2000 curie units into larger sources.

Among the fission products of uranium are two elements not yet found in the earth's crust. These are promethium, a rare earth having an atomic number of 61, and technetium, an element resembling manganese and rhenium, with an atomic number of 43. All of the isotopes of promethium and technetium produced by uranium fission are radioactive. Fortunately, in one case each, the half-lives for their decay are long enough so that weighable amounts of them remain in process waste solutions. Small quantities of both elements were isolated from these intensely radioactive wastes in the "hot" laboratories at Oak Ridge recently. The chemical and physical properties of the synthetic element technetium are of particular interest. Pure metallic technetium is silver-grey in appearance and shows a very high melting point. Its density is approximately the same as that of silver, and it is slightly magnetic. Technetium dioxide occurs as a black solid resembling manganese dioxide. Elemental technetium is of interest from the point of view of a reactor material.

At Oak Ridge an improved method was developed for determining the isotopic composition of elements in extremely small amounts of solid samples. The basic method involves vaporising the sample inside a mass spectrometer and then ionising the vapour by electron bombardment or by surface ionisation. The isotopic ratios of interest can then be determined. The introduction of iridium heater strips, on which the sample is placed and subsequently vaporised, simplified and improved the technique. It was found possible to load several types of samples on a single heater strip and vaporise them separately at increasing temperatures, thus conducting several isotope assays in succession. The chemical inertness of iridium makes possible the isotopic assay of most elements in the form of any solid compound, thus simplifying the chemical pre-treatment of the samples. The surface ionisation characteristics of iridium were at least equal to those of other materials used.

An unusual opportunity for research is afforded by the abundant supply of neutrons emerging as beams from several reactors of the A.E.C. The diffraction of such neutrons by crystalline substances constitutes a valuable method of determining the chemical structure of the material. Neutron diffraction is similar to X-ray diffraction in that a pattern is observed either from a single crystal or from a powdered sample, in which each spot or line of the pattern corresponds to a logical scattering of the neutrons or X-rays from a recurring unit of the crystal structure. Interpretation consists in assuming a structure and in calculating from it the diffraction pattern to be expected. The calculated pattern is then compared with the observed pattern. The calculations are repeated for successive modifications of the assumed structure until the patterns match. It has been found that neutron and X-ray diffraction are complementary, and that some problems are better attacked by one than by the other. Of great chemical interest is the fact that neutron diffraction can be used to investigate the positions of hydrogen atoms in crystals, whereas X-rays usually cannot.

The relationship between pressure and melting of low-boiling gases in the solid state was investigated at the Los Alamos Scientific Laboratory with improved apparatus and techniques. The freezing and melting transitions of helium 3, helium 4, neon, nitrogen and oxygen were studied, temperatures as low as −458·1 deg. Fah. and pressures as high as 54,000 lb per square inch being used. In this work a phenomenon analogous to super-cooling was observed and has been termed "super-pressurising" at the laboratory. For example, it was found possible to apply to liquid oxygen a pressure of some 7000 lb per square inch above the normal equilibrium freezing pressure before solidification took place. It was also found possible to apply shear forces across solidified gases without appreciably changing the melting point. Dilution of oxygen with a small amount of argon raised the melting point.

The corrosion of aluminium in water at high temperatures is being studied at the Argonne National Laboratory. Serious corrosion was observed, but the corrosion resistance was remarkably improved when small quantities of certain inorganic salts were added to the water. The same effect was observed in neutral solution and in slightly acid solution, sulphuric acid being used to render the solution acidic. These corrosion inhibitors prevented blistering of the metal during a forty-eight-hour test period, and there was evidence that no blistering would occur if the test period was extended for twenty-four days.

At the Brookhaven National Laboratory the behaviour of materials of construction for reactors, such as steel, when in contact with molten bismuth are under investigation. It was shown that the mode of corrosion is by the dissolution of the steel in the hot molten metal. If the molten metal is cooled, a large fraction of the iron that is dissolved in the hot bismuth is precipitated out. Thus, in a closed circuit, such as is used in transferring heat from the reactor to a heat exchanger, the iron is transferred by the fluid from the hot region to the colder regions. It was shown that the addition of small quantities of metallic zirconium to bismuth markedly reduced this transfer. In experiments in which radioactive zirconium was used, the zirconium was deposited on the steel surfaces.

In the electromagnetic separation of stable isotopes at Oak Ridge a new ion source operating in the temperature range 1800 deg. Cent. to 2800 deg. Cent. was developed and used in obtaining, for the first time, gramme quantities of the isotopes of the refractory metals—ruthenium, palladium, iridium and platinum. The successful processing of these elements now brings to forty-eight the number of elements whose isotopes have been separated. Progress was also made in developing ion sources and isotope collectors for the production of quantities of enriched isotopes. Gramme quantities of separated isotopes are used especially in neutron cross section measurements and in the preparation of cyclotron targets for the production of essential radioactive isotopes. Many of these radioactive isotopes have important applications and cannot be obtained satisfactorily by any other means. Calcium 46, manganese 54, and iodine 130 are examples of isotopes being investigated for medical research.

At the Argonne National Laboratory it was found that alpha particles shot into helium or argon or mixtures of these gases with nitrogen gave pulses which were readily measurable with photo-multipliers, thus making possible a new type of scintillation counter. The principal advantages over other designs are high speed and insensitivity to gamma rays. At Los Alamos such counters using krypton were found to be useful for cases in which the large number of pulses would clog other counter designs.

In the field of particle accelerators, the initial operation of the bevatron at the University of California Radiation Laboratory began in February of last year, when protons were accelerated to an energy of about 5000 MeV. Performance continued to improve, and by April a proton beam energy of 6100 MeV was attained. A bombardment of targets with 6000 MeV protons is expected to produce particles previously undetected in a laboratory. There is particular interest in the use of the bevatron to study mesons. The higher energy from the bevatron is expected to open up a new range in the spectrum of these particles. Experiments are also planned with protons, neutrons and mesons, using a great many target materials to study their absorption and their scattering.

During operation of the cosmotron at the Brookhaven National Laboratory on November 5, 1954, a short circuit developed in the main magnet winding in the south-east quadrant near the south straight section, as a result of a water leak in a cooling tube. It was tentatively estimated that three to six months' shut-down time would be required for repairs. This affords an opportunity for incorporating improvements in the machine, and ejection magnets are being installed to facilitate getting the beam out of the cosmotron, thus increasing its effectiveness.

Industrial and Labour Notes

Works Managers' Conference

A national conference, arranged by the Institution of Works Managers, was held in London on Thursday, Friday and Saturday of last week. Its general theme was "Maintaining Prosperity by Efficient Management," and during the conference there was formally inaugurated an industrial engineering division which the Institution has established.

The opening address at the conference was by Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour, who spoke of the increasing importance of industrial management in this country's economy. Mr. Watkinson said that the works manager was in a key position, whether his undertaking numbered its employees by the thousands, or whether he was in a modest firm with a small pay-roll. The works manager's initiative and driving force, his courage and enterprise, and his persistence, were of the utmost value to the nation's industrial well-being. Mr. Watkinson went on to emphasise the need to make the best use of skilled men. The demand for skilled labour, he said, could be met only if it was recognised that skilled labour was not to be picked up simply for the asking, and all the country's resources were utilised in a careful and intelligent way. The future development of atomic energy and of new manufacturing techniques would greatly increase the skilled labour demand. There must also be borne in mind, therefore, Mr. Watkinson added, the importance of training and apprenticeship as a longer-term policy.

Mr. Watkinson then referred to the need for goodwill and co-operation between management and workpeople, which, he said, could be developed into a "powerful urge towards efficiency." Machines or management or production techniques might be highly efficient, but they could fail to give the best results if the general morale of an establishment was low where it should be high and enthusiastic. Efficient industrial production, Mr. Watkinson commented, was not the automatic result of new methods or new machines. It could only come from teamwork, and good teamwork meant not only good leadership but good understanding.

Coal Supplies

Several questions about coal imports were asked in the House of Commons on Monday. In reply to them, the Parliamentary Secretary to the Ministry of Fuel and Power, Mr. L. W. Joynson-Hicks, said that in the twelve months ended February 28th, 4,235,000 tons of coal were imported into this country. Of that amount, 935,000 tons came from the U.S.A. and Canada, and 3,300,000 tons from other sources. Mr. Joynson-Hicks added that currency considerations were amongst those affecting the question from where coal was imported, but there were other questions, such as the availability of required grades, prices and shipping facilities. In the twelve months ended February 28th, Mr. Joynson-Hicks stated, the c.i.f. value of coal imports was £24.000,000 and the f.o.b. value of coal exports was £58,000,000.

The latest figures from the Ministry of Fuel and Power about this country's coal output show that in the first thirteen weeks of this year, ended last Saturday, it amounted to 58,762,900 tons, compared with 59,830,900 tons in the corresponding weeks of last year. Production from the deep mines so far this year is now about 600,000 tons lower than in the comparable period of 1954, and the quantity gained from opencast workings is about 450,000 tons less. Last week's production, totalling 4,698,000 tons, was 70,000 tons higher than in the comparable week of last year. The losses of deep-mined output, so far this year, through disputes and recognised holidays, have been estimated at 862,900 tons. Colliery manpower continues to be around 708,000, of whom 290,700 are working at the face. Absenteeism in the week ended March 26th was 13·11 per cent, which was slightly higher than a year earlier, but output per manshift at the face, at 3·317 tons, was an improvement on that achieved in the corresponding week of 1954. Total coal consumption in the first twelve weeks of this year was 60,806,000 tons, which figure includes exports amounting to 2,581,000 tons.

Index of Industrial Production

The central statistical office of the Treasury has stated that the provisional index of industrial production (1948=100) in all industries in the United Kingdom in January was 133, compared with a revised figure of 129 for December. The figures for the corresponding months a year earlier were 127 in January, 1954, and 121 in December, 1953. In the manufacturing industries only, the index number for January this year has been computed as 137, compared with 129 a year earlier; for mining and quarrying, the index was 114 against 117 in January, 1954.

Changes in Wage Rates

The Ministry of Labour has stated that changes in wage rates, reported to have come into operation in the United Kingdom in February, resulted in an aggregate increase of about £392,000 in the weekly full-time wages of 1,937,000 workpeople. Among those receiving increases were workers in building and civil engineering contracting, railway workshop employees, bus drivers and conductors and maintenance staff employed by London Transport, and those engaged in goods transport by road.

In building and civil engineering contracting, sliding scale arrangements based on the index of retail prices gave an increase of one halfpenny an hour to adult workers. The increases to railway workshop staff, which were payable retrospectively from January, were 10s., 11s. 6d. or 13s. a week for men, according to occupation. London Transport bus and coach drivers and conductors received increases of 9s. 6d. or 13s. 6d. a week, according to length of service. Maintenance staff in London Transport garages and depots received 7s. 4d. a week. In the road haulage industry, by an agreement of the National Joint Industrial Council, there was an increase of 10s. a week for adult workers employed in goods transport.

In the first two months of this year, changes in wage rates resulted in an aggregate increase of £1,163,100 in the weekly full-time wages of approximately 4,695,500 workpeople, compared with an aggregate increase of £643,000 in the wages of 2,715,000 workpeople in the corresponding months of last year. At the end of February the index of rates of wages (June 30, 1947=100) stood at 146 for all workers.

Average Weekly Earnings

In these notes in our issue of March 4th, reference was made to the result of the inquiry into average weekly earnings of manual workers in the United Kingdom which the Ministry of Labour conducted last October. More detailed information about this inquiry has now been published in the *Ministry of Labour Gazette*. The figures relate to the earnings, in the last pay-week in October, 1954, of about 7,000,000 manual workers in the manufacturing industries and in a number of the principal non-manufacturing industries. Among the principal employments excluded from the inquiry, however, were agriculture, coal mining, British Railways, London Transport, British Road Services, the shipping service, and port transport.

The Ministry's figures show that in all the industries coming within the scope of the inquiry, the average earnings in the last pay week in October, 1954, were: men, £10 4s. 5d.; youths and boys, £4 5s. 7d.; women, £5 8s. 2d.; girls, £3 9s. 5d., the average hours worked being men, 48·5; youths and boys, 44·9; women, 41·9; girls, 42·8. In the manufacturing industries only, the average earnings in the week surveyed were: men, £10 12s. 3d.; youths and boys, £4 3s. 8d.; women, £5 8s. 11d.; girls, £3 9s. 11d., the average hours worked being 48·5, 44·5, 42 and 42·9 respectively. The manufacturing industries include, of course, a group classified as "engineering, shipbuilding and electrical goods." In this group, the average earnings in the last pay week of October were: men, £10 15s. 7d.; youths and boys, £4 1s. 2d.; women, £8 16s 7d.; girls, £3 12s. 6d., the average hours worked being 49, 44·3, 42·8 and 43·1 respectively. The Ministry's survey states that, in the manufacturing industries, the percentage increases in average earnings in October last, compared with October, 1938, were: men, 199 per cent; youths and boys, 223 per cent; women, 232 per cent; and girls, 276 per cent.

Steel Works Development in India

Last week-end a United Kingdom steel mission, under the leadership of Sir Eric Coates, left for India, where it is to advise on the establishment of a new steel works. A request for the mission was made recently to the Commonwealth Relations Office by the Government of India.

It is stated that the mission will study, in consultation with Indian experts, the capacity of the proposed works, the range of end products, and the processes to be employed. It will also assist in the preparation of estimates of the cost of the plant and equipment to be imported, and of the local costs, including acquisition of land, provision of rail, power, housing and other facilities, as well as the cost of production at the new works. In addition, the mission is to make estimates of the manpower needed for the plant and suggest arrangements for the recruitment and training of Indian personnel.

The mission, which is being provided under the technical co-operation scheme of the Colombo Plan, will report to the Government of India on the completion of its work. Its membership includes representatives of the British Iron and Steel Federation, the British Iron and Steel Research Association, and of the steel works equipment industries, and an electrical consultant.

London Newspaper Printing Dispute

As these notes go to press, the strike of electricians and maintenance engineering workers in the printing offices of London's morning and evening newspapers continues. The strike began on Friday, March 25th—since when the London morning and evening papers have not been published—and the few hundred men directly concerned in it are members of the Electrical Trades Union and the Amalgamated Engineering Union. These unions are not attached to the Printing and Kindred Trades Federation.

The two unions involved are claiming a wage increase of £2 18s. 6d. a week for their members working in London daily and evening newspaper printing establishments, which, it has been stated, would raise the basic rates to about 125 per cent of their pre-war level. The Newspaper Proprietors Association, in negotiations on a revision of wage agreements, had offered increases which were not accepted by the two unions. The Association then suggested that the matter should go to a court of arbitration, and undertook in advance to accept the decision of such a court. The unions, however, refused to consider that suggestion. Last Friday, representatives of the two unions and of the Newspaper Proprietors' Association had separate talks with the chief industrial commissioner of the Ministry of Labour. Following those talks, it was announced that the Minister of Labour had appointed a Court of Inquiry, with Sir John Forster, Q.C., as chairman, to examine immediately the circumstances of the dispute. In setting up the court, the Minister expressed the hope that the two unions concerned would recommend an immediate resumption of work so that the inquiry could proceed in a strike-free atmosphere. In the House of Commons on Monday, the Minister of Labour, Sir Walter Monckton, Q.C., said he regretted that that hope had not been realised. He felt that, now that an impartial inquiry into the whole dispute was being conducted, the trade unions concerned should recommend their members to return to work without delay.

The Court of Inquiry began its sittings, in public, on Wednesday morning.

Personal and Business

Appointments

MR. R. A. ROBERTSON has been appointed a managing director of Bowmaker, Ltd.

MR. J. PRICE has been appointed sales manager of Pollard Bearings, Ltd., Ferrybridge, Knottingley, Yorks.

MR. STANLEY S. DAWES, M.I.Mech.E., has been elected president of the Institute of the Motor Industry.

DR. E. G. WOODROOFE has been appointed head of the research division of Unilever, Ltd., in succession to Dr. H. J. Channon.

MR. E. J. BATCHELOR has been appointed general manager of the automobile division of the David Brown Corporation, Ltd.

MR. JOHN G. PARK, M.I.E.E., Hadley Wood, Herts, has been appointed electrical engineering adviser to the Government of Ceylon.

MCKECHNIE BROTHERS, Ltd., announces the appointment of Mr. E. C. Snelus as sales manager at its metal works at Rotton Park Street, Birmingham.

CAPPER PASS AND SON, Ltd., Bristol, states that Mr. C. G. L. Francis has been appointed chief engineer, in succession to Mr. B. T. C. Sawyer, who has retired.

MR. A. HOLROYD, sewage works manager, Wolverhampton, has been appointed a member of the Water Pollution Board of the Department of Scientific and Industrial Research.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION announces the appointment of Mr. F. J. Girling as principal officer in the marine survey service, East of Scotland district, Leith.

MR. A. KENDALL has joined Igranic Electric Company, Ltd., as radio buyer. He will operate from the company's radio and television componeat factory at Bromborough, Cheshire.

MR. D. J. SAUNDERS, formerly a principal scientific officer in the rocket propulsion department of the Ministry of Supply, has been appointed chief development engineer (hydraulics) of the Compoflex Company, Ltd.

DR. J. CRAIK has been appointed chairman of the Nobel division of Imperial Chemical Industries, Ltd., in succession to Dr. W. J. Jenkins, who has retired. Dr. Craik, who joined I.C.I. in 1927, has been a managing director of the Nobel division since November, 1953.

MR. J. P. A. MELDRUM and Mr. R. H. S. Turner have been appointed directors of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester. Mr. Meldrum has been manager, home sales, since January, 1953, and Mr. Turner has been works manager at Trafford Park since April, 1954.

SUNVIC CONTROLS, Ltd., 10, Essex Street, Strand, London, W.C.2, states that Mr. D. M. Gill has been appointed technical representative for the process control division in N.W. England. Mr. F. N. Yates, 36A, Brownsville Road, Heaton Moor, Stockport, has been appointed representative in the same area for the scientific and industrial divisions. Mr. W. F. Dorman has been appointed to represent the scientific and technical divisions, and Mr. F. C. Chaventre, the process control division, in the London and Home Counties area.

Business Announcements

BROOK MOTORS, Ltd., Huddersfield, states that its Swansea branch has been moved to 93, Walter Road, Swansea (telephone, Swansea 57559).

MR. HEDLEY LLOYD, export director of Marsh Brothers and Co., Ltd., Sheffield, has left for a business tour in Ceylon, Australia and New Zealand.

THE EXPORT CREDITS GUARANTEE DEPARTMENT states that its Sheffield office has now been moved to Orchard Chambers, 27A, Church Street, Sheffield, 1 (telephone, Sheffield 29151).

THE BRITISH OVERSEAS AIRWAYS CORPORATION announces the retirement of Mr. G. A. Hummerstone, from the position of engineering manager at the Corporation's repair factories at Treforest.

WM. NEILL AND SON (ST. HELENS), Ltd., has completed arrangements for taking over the works of Alltons (Structural Steel), Ltd., which are situated on the Parr Industrial Estate, St. Helens, Lancs.

MR. J. E. CALVERLEY, M.I.E.E., M.I.Loco.E., recently retired from The English Electric Company, Ltd. Mr. Calverley was appointed deputy chief engineer (technical) to the company in 1943 and, since 1952, he has been engaged on special consultancy duties with this firm. There one of his main interests has been in direct current work and rectification. He was associated with the late Mr. W. E. Highfield in the development of the transverter.

FERODO, Ltd., states that it has transferred the manufacture and sale of "Ferobestos" plastics to its associated company, J. W. Roberts, Ltd., Chorley New Road, Lostock, Bolton. Ferodo, Ltd., announces also that it has opened a new depot in Nursery Street, Sheffield, under the management of Mr. W. H. Wyse.

Contracts

VICKERS-ARMSTRONGS, Ltd., announces that a contract for the supply of 100 "Centurion" Mk. 3 tanks and spares equipment to the Swiss Government was signed in Berne on March 31st.

BIRLEC, Ltd., has recently been commissioned by the Head, Wrightson Machine Company Ltd., Middlesbrough, to build a continuous driven roller hearth annealing and galvanizing furnace for installation at a South Wales steel works. It will handle steel strip of up to 48in width at an output of 10 tons per hour. The installation will be over 300ft in length, the heating furnaces being accommodated on a staging over 20ft high. The combined electrical rating of furnace elements, drive gear, etc., will be approximately 1000kW and the gas consumption (using coke oven gas, which is available on site) about 30,000 cubic feet per hour. Three methods of furnace heating will be employed: open gas burners for preheating, gas-fired radiant tubes, and electrical resistance elements, for zones where very close temperature control is required and for heating the galvanizing bath. Carefully maintained atmosphere conditions will be required in all parts of the furnace, except the preheating zone; the highly reducing gas will be derived from a specially constructed ammonia cracker plant.

Miscellanea

HIGHER FEES FOR TRADE MARKS.—The Board of Trade has stated that as from April 1st, higher renewal fees are charged for trade mark registrations due to expire after June 30, 1955; and after the latter date there is to be a general increase in the fees payable in respect of a number of trade marks matters. It is explained that the fees have remained substantially unchanged for many years despite considerable increases in administrative costs. A similar announcement regarding higher renewal fees for patents and designs was made at the end of January.

AGRICULTURAL ENGINEERS ASSOCIATION.—The first annual general meeting of the Agricultural Engineers Association, since its recent incorporation under new articles of association, was held in London on March 30th. At the meeting, Mr. D. P. Ransome, M.I.Mech.E., M.I.B.A.E., managing director of E. H. Bentall and Co., Ltd., was elected president. Two vice-presidents were elected as follows: Mr. W. D. Akester, sales director of Ransomes, Sims and Jefferies, Ltd., and Mr. Lionel Harper, managing director of Massey-Harris-Ferguson (Sales), Ltd.

ROYAL SHOW AT NOTTINGHAM.—The Royal Agricultural Society says that at its annual show, which will be held at Nottingham from July 5th to 8th, the total stand space allocated to machinery and equipment is approximately 1,300,000 square feet. The area of the whole showground extends to 165 acres, a larger acreage than in any year since the Royal Show started in 1839. The Society's implement committee has accepted nineteen entries, from thirty-seven submitted, for judging for silver medal awards. In addition, there are five entries for judging which were deferred from last year.

SIR WILLIAM J. LARKE'S EIGHTIETH BIRTHDAY.—Sir William J. Larke, K.B.E., who will be eighty on April 26th, is to be the guest of honour at a luncheon organised by the Institute of Welding and the British Welding Research Association at the Hyde Park Hotel, London, on April 25th. The chair will be taken by Sir Claude Gibb, F.R.S., supported by Sir Charles Lillicrap, chairman of council of the British Welding Research Association, and Mr. R. G. Braithwaite, president of the Institute of Welding. Further particulars and tickets are obtainable from the Secretary, Institute of Welding, 2, Buckingham Palace Gardens, London, S.W.1.

CONFERENCE ON PRODUCTION AND UTILISATION OF ELECTROMAGNETICALLY ENRICHED ISOTOPES.—A conference on the production and utilisation of electromagnetically enriched isotopes will be held at the Atomic Energy Research Establishment, Harwell, from September 13th to the 16th next. Members of the team responsible for the work on stable isotopes at Oak Ridge, U.S.A., are attending and provisional acceptances have been received from leaders of the separator groups in France, Holland and Denmark. Although a detailed programme has not yet been prepared, sessions will be included on: design and operation of large mass separators; ion source and collector problems especially with high beam current; separation of radioactive materials; chemical aspects of the production work; preparation of isotopic targets; developments in stable isotopes mass-analysis; utilisation of electromagnetically enriched isotopes. Much of the meeting will be occupied with problems of the electromagnetic separator itself but contributions will also be welcomed on applications of stable isotopes, especially unusual ones; the emphasis will be on principles rather than details of techniques. Work on the application of the isotopes of the lighter elements, particularly of hydrogen, carbon, nitrogen and oxygen which are more economically enriched by other methods, is specifically excluded. Further particulars can be obtained from Dr. M. L. Smith, A.E.R.E., Harwell, Didcot, Berks.

SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Arrangements are now being made by the Birmingham and District Industrial Safety Group for the third Safety and Factory Efficiency Exhibition which is to be held in the Bingley Hall, Birmingham, from June 24th to July 1st. During the first week-end of the exhibition, June 24th to 26th, there is to be a congress under the general title "Social and Factual Examination of Industrial Accidents." The organising secretary of the exhibition is Mr. W. G. Appleyard, Industrial Safety Training Centre, Museum of Science and Industry, Newhall Street, Birmingham, 3.

EUROPE'S MACHINE TOOL INDUSTRY.—The European Committee for Co-operation of the Machine Tool Industries has recently held a meeting in London, at which a new board was elected. At present, eight national machine tool associations are represented on the committee. Dr. Gerhard Schaudt (Germany) was elected president of the European committee; Monsieur Felix Leblanc (Belgium), Monsieur Emmanuel Pouvreau (France), Mr. Robert Asquith (Great Britain), Monsieur Georges Fischer (Switzerland), and Count Galileo Motta (Italy), were elected vice-presidents, and Monsieur Frederick Maurice (Switzerland) was elected president of the exhibition sub-committee.

POST-GRADUATE BURSARIES IN ELECTRICAL AND MECHANICAL ENGINEERING.—Metropolitan-Vickers Electrical Company, Ltd., of Trafford Park, Manchester, has endowed four Post-Graduate Bursaries in electrical and mechanical engineering, each of £400 per annum, in the University of Manchester; two of these bursaries will normally be tenable in the Faculty of Technology of the University at the Manchester College of Technology. The company has also endowed three similar bursaries tenable in the Mechanical and Electrical Engineering Departments at the Imperial College of Science and Technology, London. A particular purpose of these bursaries is to encourage graduates in physics and mathematics to undertake post-graduate study or research in engineering in preparation for entry into the electrical industry.

CORROSION BY FERTILISERS.—A conference on "The Problems of Corrosion by Fertilisers," which has been arranged by the Institution of British Agricultural Engineers and the Fertiliser Society, is to be held at the Royal Society of Arts, 6, John Adam Street, Adelphi, London, W.C.2, on Thursday, April 21st. At the morning session, beginning at 10.30 a.m., the following papers will be discussed jointly: "The Chemistry and Metallurgy of Corrosion of Metals, &c., by Fertiliser Materials," by Dr. W. D. Clark, and "Methods Used by Manufacturers to Reduce Corrosiveness of Fertilisers," by Mr. J. E. Nicholson. At the afternoon session at 2.30 p.m., the papers for discussion are: "The Corrosion of Steel in Agriculture," by Mr. C. R. Pipe, and "Problems of Corrosion Prevention on the Farm," by Mr. R. M. Paterson.

RURAL ELECTRIFICATION.—A luncheon in honour of Mr. G. H. Johnstone, who has just retired from the South Western Electricity Board, was held at St. Ives, Cornwall, on Friday, April 1st. Speaking at it, Mr. S. F. Steward, chairman of the Board, said that the contribution which Mr. Johnstone had made to the development of rural electrification was to be perpetuated by a lectureship at the Seale-Hayne Agricultural College, Newton Abbot. It would be known as the George Johnstone lecture and would be given annually by a leading authority on some aspect of rural electrification. One of the problems, Mr. Steward added, was to secure a wider appreciation of the advantages to be gained from a full use of electricity in agriculture, and to keep farming and horticultural circles abreast of the developments which were taking place.

BOOKLETS ON CONCRETE AND SOIL-CEMENT ROAD CONSTRUCTION.—The Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, has prepared a series of technical booklets describing the design and construction of concrete and soil-cement roads. The Association points out that concentration on the past and on research alone without concurrent full-scale practice is leading to an over-emphasis on problems which might well dissolve or become much less important in the atmosphere of actual construction. It is thought, therefore, that the time has come when the lessons learnt from past mistakes and from research should be set down in a form suitable for application in the field, and the purpose of the Association in preparing these booklets has been to outline the latest methods of design and construction in as straightforward and definite a way as possible. Four booklets are being issued at the present time, dealing with concrete roads and one with soil-cement. The concrete road booklets are: No. 1, "Earthworks, Sub-grades and Bases"; No. 2, "Slab Design"; No. 3, "Design of Mixes," and No. 4, "Construction Methods." Further booklets dealing with specialised aspects of concrete road construction, for example, on housing estates, and specifications incorporating the recommendations in the booklets, are being prepared. The booklet on soil-cement roads is a new version of the previous booklet issued by the Association some years ago.

British Patent Specifications

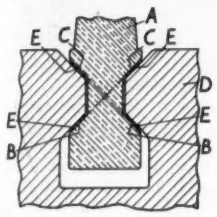
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

GAS TURBINES

724,805. February 24, 1953.—Turbine Rotor of Steel having Ceramic Blading, Maschinenfabrik Augsburg-Nurnberg A.G., Stadtbachstrasse 7 (13b), Augsburg 2, Germany.

The drawing shows a section through the fixing point of a ceramic blade in a slot in a steel rotor disc, the blade root being provided with two pairs of seating faces arranged one above the other such that their surface planes intersect to form a double cone. The ceramic blade *A* has a root part on which there are two pairs of seating faces *B* and *C*. One pair of seating faces *B* mainly receives tension forces arising from centrifugal force, whilst the other pair



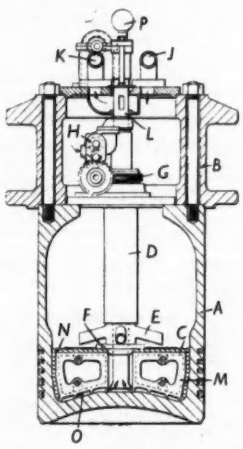
No. 724,805

of seating faces *C* position and retain the blade in the slot of the rotor disc rim *D*. The mutual inclination of the two pairs of seating faces is selected so as to ensure a connection which is substantially independent of temperature. In order to obtain the smallest possible angles of inclination between the two pairs of seating faces whilst using this blade root construction metal inserts *E* are placed between the corresponding bearing surfaces of the blade and the slot. In this way, it is possible to alleviate frictional effects between the abutting ceramic and steel surfaces.—*February* 23, 1955.

INTERNAL COMBUSTION ENGINES

725,227. June 10, 1953.—Cooling the Upper Pistons of Opposed Piston Engines, William Augustine Harper, Cuthbert Coulson Pounder and Sir Frederick Ernest Rebbeck, all of Harland and Wolff, Ltd., Queen's Island, Belfast, Northern Ireland.

The invention relates to vertical opposed-piston, compression-ignition engines, and provides improved means for the better cooling of the upper pistons. Referring to the drawing, *A* is the upper piston of the engine, having a yoke *B* secured to the piston. A



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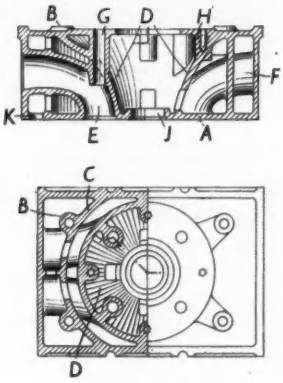
coolant circulator *C* fitted to the lower part of the interior of the piston is attached to coolant flow and return pipes enclosed in a tubular casing *D*. This casing is insulated from a tube with branches *E* giving a swirling motion to the coolant. A flange *F* is driven by the circulator through pins. The casing *D* has teeth at its upper end which engage teeth on a bush fixed to a worm wheel *G* rotated by a motor *H*. This motor is driven by the flow of coolant, which is introduced into the yoke through pipe *J*. The coolant finally leaves the yoke through an outlet pipe *K* after passing through the circulator and rising up through a return pipe *L*. To prevent hammer action by inertia forces, the return pipe *L* is held down by a spring which rests on an anti-friction bearing on the top of the pipe. The circulator incorporates a series of scrapers *M* built up in segments. Each segment has an inlet passage *N* for the coolant discharged by the distributor branches *E* and ribs forming flow passages *O* are machined to conform to the internal contour of the piston. The rotation of the circulator is indicated by a disc *P* on the top of the pipe *L*. The specification also shows a hand-operated chain-wheel drive for operating the circulator when the engine is stopped and modified forms of scraper drives.—*March* 2, 1955.

724,461.—April 1, 1953.—Cylinder Heads, Maybach-Motorenbau G.m.b.H., Friedrichshafen, a.B., Germany.

The invention relates to liquid-cooled cylinder heads for use with high-speed, overhead-valve, fuel injection, internal combustion engines having a cylinder bore of not less than 150mm and designed



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for use in motor vehicles. Referring to the drawing *A* is the lower wall of the cylinder head, facing the interior of the cylinder. *B* are bores for the cylinder head fixing bolts, formed integrally with a vertical reinforcing wall *C*. *D* is a substantially funnel-shaped reinforcing wall which is integral with the portions of the walls of the inlet and outlet valve passages *E* and *F* nearest the axis of the cylinder head. Valve guides *G* and also cover-fastening screw sockets *H* penetrate the wall. *J* indicates an opening in the centre of the lower wall, into which, for example, the communicating passage for a separate combustion chamber, or an injection nozzle, can be fixed. The cooling agent enters the head through an opening *K*. A similar design for a head with six valves is also shown in the specification.—*February* 23, 1955.

CIVIL ENGINEERING

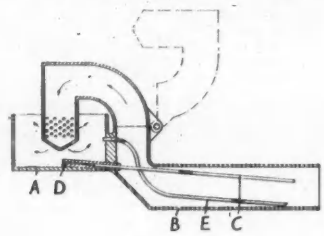
663,568. December 3, 1948.—The Production of Concrete, George Edward Bessey, the Building Research Station, Bucknalls Lane, Garston, Watford, Hertfordshire.

The invention relates to the production of lightweight concretes by processes in which air voids are incorporated in the mix before hardening. According to the invention in such a process a part or the whole of the finely divided aggregate consists of ash from pulverised coal-burning installations. The pulverised fuel ash is used in conjunction with hydraulic cement or lime, with or without the addition of sand or other aggregate in the manufacture of lightweight concrete by a process using foam-stabilising or other surface-active agents to incorporate and stabilise gas bubbles in the material. The pulverised fuel ash may be used in lightweight concrete cured either at ordinary temperatures, in steam at atmospheric pressure and elevated temperatures, or in steam at high pressure in autoclaves. Curing in steam at high pressure is preferred and gives a material of particularly high strength for any given density.—*February* 23, 1955. (Amended specification.)

BURNERS AND SPRAYERS

725,120. October 16, 1953.—Oil Burners, Nu-Way Heating Plants, Ltd., Vines Lane, Droitwich, Worcester. (*Inventor: Bror Ingmar Wennman.*)

Referring to the drawing, the oil receptacle *A* of the burner is of basin shape. This receptacle is secured to or formed on one end of an air supply pipe *B*. The oil is conducted to the receptacle by a pipe *C* which terminates in a nozzle *D* at the base of the receptacle. Return of oil from the receptacle to a supply tank, in the event of flooding, as a result of extinction of the flame, is effected by a pipe *E*. The end of the air pipe adjacent to the oil receptacle is turned up as shown, and on its upper end there is hinged an extension of inverted U-shape which terminates in a perforated nozzle. The nozzle is situated centrally and extends down almost to the bottom of the receptacle. The entrance end of the return pipe *E* is situated at about the level of the lower end of the nozzle. When it is required to clean the receptacle and the nozzles the air nozzle can be swung about the hinge to the position indicated by dotted lines. When the burner is in action the receptacle and



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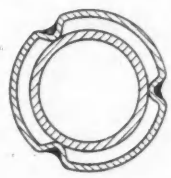
nozzle are heated by the flame surrounding the nozzle, and the hot air issuing from the nozzle promotes rapid vaporisation of the oil, the flame being supported by the mixture of air and oil vapour in the receptacle. Normally, the oil level does not rise to the level of the entrance to the pipe *E*, but in the event of extinction of the flame the oil level rises and the oil is returned by the pipe.—*March* 2, 1955.

HEAT EXCHANGERS

725,075. June 25, 1953.—Tubes for Heat Exchangers, Mannesmann Aktiengesellschaft, Mannesmannufer 1b, Düsseldorf, Germany.

The invention consists of a double tube for heat exchangers in which the outer tube is maintained at a



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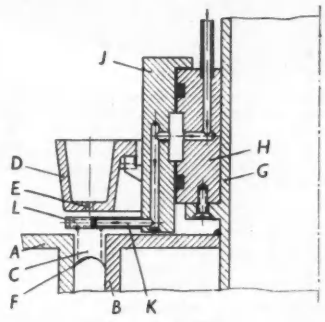
distance from the inner tube by indentations in the outer tube. The wall of the outer tube is thickened locally by built-up welding at the base of the indentations, as shown in the drawing.—*March* 2, 1955.

METALLURGY

725,893. June 30, 1953.—Mould Lubricating in Continuous Casting, Eisenwerke Gelsenkirchen Aktiengesellschaft, Gelsenkirchen, Hohenzollernstrasse 2-4, Germany.

In continuous casting it is desirable to provide and maintain a film of lubricant between the metal poured into the mould and the working or profile forming surfaces of the mould. Referring to the drawing, there is provided an annular mould *A* with a core *B* protruding into it for the continuous casting of a tubular section. Liquid metal is poured into an annular space *C* from a rotary pouring vessel *D*, which is provided with nozzles *E*. On rotation of the vessel the metal from the nozzles flows on to continuously changing localities of the surface *F* of the metal already in the mould. The core *B* is stationary and is attached to a support *G* through to a journal *H*.



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The vesssel *D* is supported on a bearing *J* which can be rotated about the journal *H*. Below the vessel *D* there are attached to the bearing *J* supply tubes *K* and *L*, which have apertures for guiding a lubricant from the tubes to the inner walls of the mould and the outer surfaces of the core. The lubricant is fed from the stationary journal through a gland to the rotary bearing.—*March* 9, 1955.

Launches and Trial Trips

WORLD GUIDANCE, oil tanker; built by Kieler Howaldswerke for Niarchos (London), Ltd.; length overall 665ft, length between perpendiculars 629ft 11in breadth moulded 86ft 7½in, depth moulded 45ft 11 $\frac{5}{8}$in, deadweight 32,500 tons, summer draught 34ft 5in, speed 17 knots; thirty cargo oil tanks, four 1000-ton horizontal, two-stage, centrifugal pumps, two 600kW turbine-driven alternators, one 100kW diesel-driven alternator; one set of geared turbines, 17,500 maximum s.h.p. at 110 r.p.m., 16,500 normal s.h.p. at 108 r.p.m. of propeller, propeller four blades, diameter 22·95ft by 14·3ft pitch; two Foster Wheeler "D" boilers supply steam at 600 lb per square inch and 830 deg. Fah. Launch, March 4th.

WORLD GUARDIAN, oil tanker, sister ship to "World Guidance." Trial, March 5th.

THESEUS, cargo liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Alfred Holt and Co.; length overall 489ft, breadth moulded 64ft, depth moulded to upper deck 35ft 3in, deadweight 9650 tons, gross tonnage 7804, service speed 16 knots; seven holds and 'tween decks, No. 3 and No. 4 holds and 'tween decks insulated, No. 5 hold arranged as deep tank; fourteen 5-ton, four 7-ton, six 10-ton derricks, and one to lift 50 tons; electric deck machinery, four ram electro-hydraulic steering gear; three 350kW diesel-driven generators, and one 350kW steam-turbine-driven generator, one 40kW diesel-driven emergency generator; Metropolitan-Vickers three-cylinder, cross-compound, impulse turbine, 8000 s.h.p. at 112 r.p.m. of propeller, two Foster-Wheeler single-furnace boilers, one John Thompson "La Mont" auxiliary boiler. Trial, March 5th.

BLACK PRINCE, cargo ship; built by the Burntisland Shipbuilding Company Ltd., for the Prince Line, Ltd.; length between perpendiculars 345ft, breadth moulded 52ft 7in, depth moulded to shelter deck 32ft 4in, deadweight 4900 tons on 21ft 9½in draught; twelve passengers; ten 5-ton, two 10-ton and one 25-ton derricks, steam winches; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 110 r.p.m. Trial March 8th.

PHAROS, lighthouse tender; built by the Caledon Shipbuilding and Engineering Company, Ltd., for the Commissioners of Northern Lighthouses; length between perpendiculars 235ft, breadth moulded 40ft, depth moulded 19ft 6in, draught 13ft, speed 14 knots; forward hold for stowage of buoys, one 15-ton, one 6-ton and two 3-ton derricks, electric deck machinery, three 90kW diesel-driven generators; two 7-cylinder Polar two-cycle, single-acting diesel engines, each of 985 b.h.p. at 220 r.p.m. Launch March 9th.

BARANA, tug; built by John I. Thornycroft and Co., Ltd., for the Government of Ceylon; length overall 122ft 6in, length between perpendiculars 115ft, breadth moulded 31ft 6in, depth moulded 14ft 6in, draught maximum 13ft, gross tonnage 350; trial speed 11 knots, static pull 18 tons; two sets of triple expansion reciprocating steam engines, total power 1400 i.h.p. at 125 r.p.m., steam supplied at 200 lb per square inch by two oil-fired Scotch boilers. Launch March 9th.

PORT MELBOURNE, cargo liner; built by Harland and Wolff, Ltd., for the Port Line, Ltd; length overall 533ft, length between perpendiculars 498ft, breadth moulded 70ft, depth moulded to upper deck 42ft, gross tonnage 9800; twelve passengers; three complete steel decks, six holds, including three insulated, eight watertight bulkheads, one 70-ton, four 15-ton, ten 10-ton derricks, two deck cranes, electric deck machinery; four 360kW diesel-driven generators; two Harland and Wolff single-acting, opposed-piston diesel engines, six cylinders, 750mm diameter by 2000mm combined stroke, heavy grade fuel oil, 112 r.p.m., two composite boilers. Launch March 10th.

Catalogues

VOSS INSTRUMENTS, Ltd., Faraday Court, High Street, Malden, Essex.—Booklet of industrial thermometers.

THE PLESSEY COMPANY, Ltd., Ilford, Essex.—Booklet entitled, "A Visual Impression of the Plessey Organisation."

HOLOPHANE, Ltd., Elverton Street, Westminster, London, S.W.1.—Catalogue of Holophane "In-Bilt" Lighting.

THOMAS ROBINSON AND SON, Ltd., Railway Works, Rochdale.—Folder illustrating Robinson woodworking machinery

DELORO STELLITE, Ltd., Highlands Road, Shirley, Birmingham.—Leaflet describing bandsaws tipped with Deloro Stellite.

GRANT PRODUCTION COMPANY, Ltd., 4, Rathbone Place, Oxford Street, London, W.1.—Booklet "Grant Throws Light on Your Problems."

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 5010, Industrial Vacuum Cleaning.

GRIFFIN AND TATLOCK, Kemble Street, Kingsway, London, W.C.2.—Booklet G.T. 1465, illustrating and describing the "Courtauld Atomic Models."

TURNER AND BROWN, Ltd., Davenport Works, Davenport Street, Bolton.—Specification sheets of "Turbro" centrifugal fans constructed entirely from rigid P.V.C.

DRUMMOND PATENTS, Ltd., 5, Great Winchester Street, London Wall, London, E.C.2.—Leaflet describing the Drummond compressed-air oil and moisture extractor.

OPANCOL, Ltd., 3-4, Sherwood Street, London, W.1.—List of products and brochure describing vane anemometers made by Wilh. Lambrecht, of Gottingen, German Federal Republic.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 13th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion Meeting on "The B.B.C., V.H.F., F.M. Sound Broadcasting Service," opened by K. R. Sturley and F. T. Lett, 6.30 p.m.——N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "The Manchester University Electronic Computer," E. T. Warburton, followed by the Annual General Meeting, 6 p.m.

Thurs., April 14th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Film Evening and Exhibition of Electronics Apparatus, 7 p.m.

Thurs., April 21st.—MERSEYSIDE SECTION: Riversdale Technical College, Riversdale Road, Liverpool, 19, Annual General Meeting, followed by Technical Films, 7 p.m.

Wed., April 27th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, S.W.1, "Suppressed Aerials for the Aircraft H.F. Band," K. J. Coppin, 6.30 p.m.——S. WALES SECTION: Cardiff College of Technology, Cathays Park, Cardiff, "Some Technical Problems in Sound and Television Broadcasting," K. R. Sturley, 6.30 p.m.

CHADWICK PUBLIC LECTURE

Wed., April 20th.—Reardon Smith Lecture Theatre, National Museum of Wales, Park Place, Cardiff, "The Role of the Public Health Inspector," Neil R. Beattie, 3.30 p.m.

ENGINEERS' GUILD

Thurs., April 14th.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, "Interplanetary Travel," G. S. Brosan, 6 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., April 26th.—Church Institute, Hull, Annual General Meeting, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., April 11th.—SHEFFIELD CENTRE: Medical Library, The University, Western Bank, Sheffield, Film Evening, followed by Annual General Meeting, 6.30 p.m.

Thurs., April 14th.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall, Manchester, "Television Studio Lighting," D. C. Lightbody, 6 p.m.

Tues., April 19th.—SESSIONAL MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Electro-Luminescence," H. C. Bate and J. N. Bowtell, 6 p.m.

Wed., April 20th.—N. LANCASHIRE GROUP: N.W. Electricity Board, 19, Friargate, Preston, Annual General Meeting, 7.15 p.m.

INCORPORATED PLANT ENGINEERS

Tues., April 12th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Care and Maintenance of Internal Combustion and Light Diesel Engines," F. N. Warmisham, 7.15 p.m.

Wed., April 13th.—E. MIDLANDS BRANCH: Adult Education Centre, Shakespeare Street, Nottingham, Film, "Diesel Engine Lubrication," 7 p.m.

Thurs., April 14th.—N.E. BRANCH: Roadway House, Oxford Street, Newcastle on Tyne, Film, "They're Everywhere," 7 p.m.

Fri., April 15th.—BIRMINGHAM MOBILE PLANT DISCUSSION GROUP: Imperial Hotel, Birmingham, "Fuel Injection and Lighting of Excavators," 7.30 p.m.

Mon., April 18th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "The Factories Acts, 1937 and 1948, as They Affect the Plant Engineer," R. E. Griffith, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., April 14th.—BEDS/HERTS SECTION: Town Hall, Luton, "Non-Ferrous Castings," H. Thompson, 7.30 p.m.

Tues., April 19th.—COVENTRY AND DISTRICT SECTION: Room A5, Technical College, Coventry, Annual General Meeting, followed by a Film Show, 7.30 p.m.——E. ANGLIAN SECTION: Central Hall, Public Library, Ipswich, Annual General Meeting, followed by Films, 7.30 p.m.

INSTITUTE OF FUEL

Mon., April 11th.—N.E. SECTION: Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, Lecture by the President, W. Idris Jones, 6.30 p.m.

Wed., April 20th.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, Visit of the President, W. Idris Jones, 2.15 p.m.

Thurs., April 21st.—E. MIDLAND SECTION: Gas Showrooms, Nottingham, Annual General Meeting, "Nuclear Power," J. Rotblat, 6.15 p.m.

INSTITUTE OF METALS

Thurs., April 14th.—LONDON LOCAL SECTION: 4, Grosvenor Gardens, London, S.W.1, Annual General Meeting, followed by a Discussion on "Recent Developments in Special Machining Techniques," 6 p.m.

INSTITUTE OF PETROLEUM

Wed., April 13th.—Manson House, 26, Portland Place, London, W.1, "Refining Methods for Maximising Middle Distillate Production," L. S. Bonnell, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., April 14th.—S. WALES GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, "Ford Diesel Engines," 7 p.m.

Thurs., April 21st.—LONDON CENTRE: Royal Society of Arts, John Adam Street, London, W.C.2, "Gas Turbines and Their Application to Road Transport," A. Enticknap, 6.30 p.m.

INSTITUTE OF WELDING

Tues., April 12th.—N. LONDON (SLOUGH SECTION): Community Centre, Farnham Road, Slough, Annual General Meeting, followed by Technical Session, 7.30 p.m.

Thurs., April 14th.—PORTSMOUTH BRANCH: Royal Beach Hotel, Southsea, Annual General Meeting and Technical Films, 7 p.m.——S. LONDON BRANCH: 2, Savoy Hill, London, W.C.2, Annual General Meeting, followed by Debate, "This Meeting Considers that all Welders Should be Certified," 6.30 p.m.

Fri., April 15th.—SHEFFIELD BRANCH: Grand Hotel, Sheffield, Annual General Meeting and Film Show, 7.15 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., April 19th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Relative Merits of Air and Water Cooling for Tractor Engines," H. Meyer, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., April 13th.—N.W. BRANCH: Grosvenor Hotel, Chester, "Engineering in Chemical Plants," O. W. Murray, 7 p.m.

Sat., April 16th.—N.W. BRANCH: College of Technology, Manchester, "Researches into Factors Affecting the Performance of Electro-Precipitators," J. R. A. Lakey and W. Bostock, 3 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., April 14th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "Present Situation on Retaining Wall Design," P. W. Rowe, 6.30 p.m.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Model Experiments on the Storm of 1953 in the Thames Estuary and the Reduction of Future Surges," Sir Claude Inglis and F. H. Allen, 6 p.m.

Tues., April 19th.—MARITIME MEETING: Great George Street, Westminster, London, S.W.1, "Reconstruction of Quays on the River Great Ouse at King's Lynn," D. V. Buck, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Thurs., April 14th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Installation of Metal-Sheathed Cables on Spaced Supports," W. Holttum, 5.30 p.m.——N. SCOTLAND SUB-CENTRE: Electrical Engineering Department, Queen's College, Dundee, "Safety in the Use of Portable and Transportable Electrical Equipment in Industry," J. W. Bunting, 7 p.m.

Mon., April 18th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Domestic Circuits and Protective Devices," opened by H. W. Swann, 5.30 p.m.——N.E. CENTRE: Royal Station Hotel, Newcastle upon Tyne, Annual General Meeting and Conversazione, 6.15 p.m.

Tues., April 19th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, Discussion on "The Measurement of Impulse Voltages and Currents, with Special Reference to the Testing of Surge Diverters," opened by R. Davis, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Problems of Hydro-Electric Design in Mixed Thermal-Hydro-Electric Systems," T. G. N. Haldane and P. L. Blackstone, 7 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 19th.—39, Elmbank Crescent, Glasgow, Annual General Meeting, "The Measurement of Ship Screws," A. Silverleaf and H. C. Garlick, 7.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., April 13th.—St. Bride Institute, Bride Lane, London, E.C.4, "Modern Plywood Technique," G. E. R. Jarman, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 20th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Operation and Running Maintenance of Locomotives on the Nigerian Railways," F. H. Jackel, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Fri., April 15th.—GENERAL MEETING, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Surface Examination by Reflection Electron Microscopy," J. S. Halliday, 5.30 p.m.

Tues., April 19th.—S. WALES BRANCH: Mackworth Hotel, Swansea, "The Design and Construction of the Uskmouth Power Station," T. H. Wood, 6 p.m.

Wed., April 20th.—E. MIDLANDS BRANCH: The University, Nottingham, "Fatigue of Metals," J. A. Pope, 7.30 p.m.——SOUTHERN BRANCH: College of Technology, Portsmouth, "Some Factors in the Selection of Machinery for Cargo Liners," L. Baker, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., April 20th.—INFORMAL MEETING: Fourth Floor, Waterloo Bridge House, London, S.E.1, "Acceptance Testing of Automatic Exchange Equipment," L. G. Tite, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Thurs., April 14th.—READING SECTION: High Duty Alloys, Ltd., Lecture Theatre, Slough, "High Cost of Low Overheads," C. H. Starr, 7.30 p.m.

Fri., April 15th.—W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Costing and Finance for Production," E. C. Sayers, 7.30 p.m.

Sat., April 16th.—PETERBOROUGH SECTION: Campbell Hotel, Bridge Street, Peterborough, Film, "Precise Measurement for Engineers," introduced by S. P. Poole, 7.30 p.m.

Mon., April 18th.—DERBY SECTION: Trongates Hotel, Trongate, Derby, "Birth of a Process: Production of Synthetic Alcohol," H. E. B. Young, 7 p.m.——1954 GEORGE BRAY MEMORIAL LECTURE: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Engineering and Production Aspects of Synthetic Fibre Manufacture," Robert Douglas, 6.45 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Thurs., April 14th.—PRESTON SECTION: Bull and Royal Hotel, Church Street, Preston, Annual General Meeting and Film Evening, 7.15 p.m.

Mon., April 18th.—MERSEYSIDE SECTION: Bradford Hotel, Liverpool, Annual General Meeting, 6.30 p.m.——S. WALES AND MONMOUTHSHIRE SECTION: College of Technology, Cardiff, Annual General Meeting and Film Evening, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., April 15th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "The Design of Materials Used in, and the Manufacture of, Pick Steels for Pneumatic Picks," C. Hutchinson, 7 p.m.

Mon., April 18th.—SHEFFIELD AND DISTRICT SECTION: Livesey-Clegg House, Sheffield, "The Organisation of an Engineering Company," F. Sargeant, 7.30 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., April 20th.—24, Dale Street, Liverpool, Annual General Meeting, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., April 14th.—Liverpool Engineering Society, 24, Dale Street, Liverpool, "Materials Resistant to Creep at High Temperatures," A. W. Franklin, Annual General Meeting, 7 p.m.

NEWCOMEN SOCIETY

Wed., April 13th.—Science Museum, South Kensington, London, S.W.7, "Windmills in Kent," Rex Wailes, Peter Davies and John Russell, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., April 15th.—Mining Institute, Newcastle upon Tyne, "The New Gear-Cutting Establishment at Clydebank," W. McLaughlin, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., April 14th.—GLASGOW BRANCH: Royal Technical College, Glasgow, "Mixed Power in Modern Aircraft," M. J. Brennan, 7.30 p.m.——GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Radio Aids for Navigation and Blind Landing," F. Ormonroyd, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Sat., April 16th.—The University, Sheffield, "Subtense Measurements," G. Hurst, 10.30 a.m.

WOMEN'S ENGINEERING SOCIETY

Wed., April 20th.—Hope House, Great Smith Street, London, S.W.1, "The Development of Bridges in the United States," Emory L. Kemp, 7 p.m.